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PROCEEDINGS

OF THE

ENGINEERS' CLUB

OF

PHILADELPHIA.

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VOL. V.

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NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

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INDEX.

NOTE.—Papers, Notes and Communications, published in this Volume by title only, are not indexed by *subjects*, but under name of *author* only.

Abutment of Chestnut St. Bridge, Strengthening the——, ... 14
Adaptation of Steel to Structural Work, ... 197
Additions to Library, See Library.
Additions to Membership, See Members.
Addresses, Annual ——, See Annual Addresses.
Addresses, Opening ——, See Opening Addresses.
Air Current in Shaft, ... 248
Albo-Carbon Light, ... 272
Allen, Kenneth. The Purification of Sewage, ... 158
Improved Protractor, ... 165
Amendment to Constitution, ... 76, 77
America, The First Permanent Tramway in ——, ... 418
Amsler's Polar Planimeter, ... 262
Annual Address of President J. J. de Kinder, ... 173
Annual Meetings, See Minutes.
Annual Report of Secretary and Treasurer, ... 255
Aqueduct, New Croton ——, ... 273
Arches, Behavior of Two Brick ——, ... 212
Arcs, Ordinates for Circular ——, Table, ... 407
Artesian (?) Wells of New York City, ... 155
Ascertaining Distances in Rectangular Cities, Co-ordinate Method of ——, . 148
Ashburner, C. A. Part I, Atlas Anthracite Coal Fields of Pennsylvania, Second Geological Survey, ... 74
Association of Engineering Societies, ... 85
Astor's Steam Yacht, ... 70
Atlantic City, N. J., Sewerage Work at ——, ... 157
Austin, T. Everett. Fast Passenger Locomotives, ... 97
Automatic Car Coupler, ... 156

Barber, D. C. The Pollution of the Upper Schuylkill, ... 159
Barnard, Prof. L. H. Stereographic Projection—Practical Methods, . . . 108
Battery, Portable Storage ——, ... 69
Beatty, James, Jr. Relative Costs of Fluid and Solid Fuels, ... 120
Beaumont Rock Drill, ... 157
Behavior of Two Brick Arches, ... 212

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Behavior of Water in a Double Siphon, ... 412
Bergner, Theodore. Drawing Boards, ... 71
Memorial, ... 403
Bigelow's Report on the Panama Canal, Notes upon Hon. John ——, . . 416
Blowing Engines, Relative Areas of Piston and Valves on ——, ... 249
Blue Lines on White Ground, Reproduction of Drawings in ——, . . . 152
Blue Print Process, ... 151
Board of Directors, Minutes of Meetings of ——, See Minutes.
Boiler, Coventry Locomotive ——, ... 268
Boilers, Calorimetric Tests of ——, ... 379
Book Notices, ... 96, 172, 426
Borup Coal Chute, ... 158
Bowen, F. H., Jr. The Albo-Carbon Light, ... 272
Boyd, John T. Amsler's Polar Planimeter, ... 262, 352
Coventry Locomotive Boiler, ... 268
Breakwater, Delaware ——, etc., ... 314
Brendlinger, P. F. A Novel Cement Testing Machine, ... 194
Brick Arches, Behavior of Two ——, ... 212
Bridge, Chestnut St. ——, ... 14
Bridge Floor Timbers, Fastenings for ——, ... 279
Bridge, Old Wernwag ——, at Philadelphia, ... 156
Bridges, Dimensions of Iron Railroad ——, ... 204
Bridges, Forth and Tay ——, ... 281
Brigantine Beach, Sand-Bag Embankment across Little Inlet, ... 117
Brooke, Walter C. Appliance for Landing Mine Cars at Top of Slope, . . 347
Buchholz, C. W. The Schuylkill River East Side R. R. Co., ... 102
Engineering; Its Achievements and Its Reward, ... 218
Burr, Prof. Wm. H. Discussion of Adaptation of Steel to Structural Work, . 202

Calorimetric Tests of Boilers, ... 379
Calumet & Hecla Mining Co., Large Hoisting Drums of ——, ... 153
Canal, Nicaragua Ship ——, ... 327
Canal Question, Present Situation of the Interoceanic ——, ... 238
Car Coupler, Automatic ——, ... 156
Car Wheels, Lathes for Turning Steel Tired ——, ... 412
Cement Testing Machine, ... 194
Chains Expressed in Feet, Table of ——, ... 346
Chance, Dr. H. M. Discussion of Sources of Pollution in Storage Reservoirs, . 13
Discussion of Chestnut St. Bridge Repairs, ... 36
The Pressure and Composition of Natural Gas, ... 365
The Behavior of Water in a Double Siphon, ... 412
Change of Name of Club, Proposed ——, ... 78, 81, 83
Chestnut St. Bridge Repairs, ... 14, 79
Chimneys, Sizes of ——, Table, ... 411
Christie, James. The Adaptation of Steel to Structural Work, . . . 197, 203
Answer to Question No. 1, ... 361
Church, W. S. The New Croton Aquaduct, ... 273, 350, 362

Chute, Borup Coal ——, ... 158
Circular Arcs, Ordinates for ——, Table, ... 407
Cities, Co-ordinate Method of Ascertaining Distances in Rectangular ——, . 148
Cities, Movement of Freight and Passengers in ——, ... 395
Civil Engineers' Convention at Cleveland, etc., . . . 349, 351, 352, 363, 364
Clarke, Thomas C. The Forth and Tay Bridges, ... 281
Cleemann, T. M. Elected Director, ... 78
Discussion of Adaptation of Steel to Structural Work, ... 201
Elected Vice President, ... 360
Club Name, See Change of Name.
Club Rooms for Entertainments, ... 364
Coal Chute, Borup ——, ... 158
Codman, J. E. Calorimetric Tests of Boilers, ... 379
Collins, T. E. Does Piston Come to Stop at End of Stroke? 406
Columbus, Ga., Water Works, ... 52
Committees, Standing —— and Board of Directors, ... 86, 364
Composition, Pressure and —— of Natural Gas, ... 365
Compressed Fuel, ... 280
Conduit, Repairs to the Philadelphia Traction Co.'s ——, ... 125
Constable, Howard. The Greathead System of Fire Protection and the Public Supply of Hydraulic Power, ... 230
Novel Rubber and Steel Spring, ... 281
Constitution, Amendment to ——, See Amendment.
Construction of Street Railways in the United States, ... 37
Contributions to the Library, See Library.
Co-ordinate Method of Ascertaining Distances in Rectangular Cities, . . . 148
Cornwall Iron Mines, Lebanon Co., Pa., ... 415
Corresponding Secretary, See Secretary.
Corthell, E. L. Memorial to Congress, ... 75
Elected to Represent Club at Cleveland Convention, ... 349
Report on Cleveland Convention, ... 352
Cost of Haulage by Mules and Locomotives, ... 150
Coventry Locomotive Boiler, ... 268
Crizuka, Mataro. Railways in Japan, ... 361
Croton Aqueduct, New ——, ... 273
Crowell, J. Foster. The Behavior of Two Brick Arches, ... 212
The Present Situation of the Interoceanic Canal Question, ... 238
Some Engineering Features of the Nicaragua Canal, ... 327
Rolling Lock Gate for Nicaragua Canal, ... 362
Cruse, A. R. Gas Burners, ... 361
Curious Freak of Mild Steel, ... 400
Customs Duty, ... 348

Dam, Fairmount ——, etc., ... 372
Dam, Movable ——, ... 273
Darrach, C. G. Discussion of Sources of Pollution in Storage Reservoirs, . . 10
Discussion of Chestnut Street Bridge Repairs, ... 24, 33
Intermittent Siphons, ... 412

Dechant, Wm. H. A Movable Dam, ... 273
A Practical Test to Operate a Distant Signal by a Wire Run through a Pipe Filled with Oil, ... 341
deKinder, Joseph J. Elected President, ... 78
Discussion of Pollution of Upper Schuylkill, ... 160
Annual Address, ... 173
Delaware Breakwater, Application of Harbor Studies to ——, ... 314
Delaware River, Movement of Ice in ——, ... 385
Derbyshire, W. H. Lathe for Turning Steel Tired Car Wheels, ... 412
Description of the Construction and Manner of Turning of the Large Hoisting Drums of the Calumet and Hecla Mining Co., ... 153
Dimensions of Iron Railroad Bridges, ... 204
d'Invilliers, E. V. The Cornwall Iron Mines, Lebanon Co., Pa., ... 415
Directors, Minutes of Meetings of ——, See Minutes.
Distances in Rectangular Cities, Co-ordinate Method of Ascertaining ——, . 148
Distant Signal Operated by Wire Run through Pipe Filled with Oil, . . 341
Donations to Library, See Library.
Double Siphon, Behavior of Water in ——, ... 412
Drawing Boards, ... 71
Dredge, Large Land ——, ... 155
Drill, Beaumont Rock ——, ... 157
Drums, Hoisting ——, ... 153
DuBarry, Joseph N. Elected Vice-President, ... 78
Dye, John H. A Co-ordinate Method of Ascertaining Distances in Rectangular Cities, ... 148

Early History of the Employment of Water Power for Supplying Phila., etc., . 372
Early Water Supply of Philadelphia, ... 268
Elliott, J. S. Recent Specifications as Affecting the Dimensions of Iron Railroad Bridges, ... 204
Embankment, Sand-Bag —— across Little Inlet, ... 117
Engineering; Its Achievements and Its Reward, ... 218
Engineering Literature, Proposed Review of ——, ... 160
Evans, W. W. Presentation of White Oak Box of Wood from Delaware River Bridge, at Trenton, 1803, ... 347

Fairmount Dam, etc., ... 372
Fastenings for Bridge Floor Timbers, ... 279
Fast Passenger Locomotives, ... 97
Faunt LeRoy, Arthur Robert. Memorial 58
Feet, Table of Chains Expressed in ——, ... 346
Fire Protection, Greathead System of ——, ... 230
Fire Protection in Mills, ... 70
First Permanent Tramway in America, ... 418
Floor Timbers, Fastenings for Bridge ——, ... 279
Fluid and Solid Fuels, Relative Costs of ——, ... 120
Formulæ for Two Sides and Included Angle When Logs. are used instead of Distances, ... 68

Forth and Tay Bridges, ... 281
Freak of Mild Steel, ... 400
Free Entry at Custom House, ... 348
Freight and Passengers in Cities, Movement of ——, ... 395
Frogs and Switches, ... 63
Fuel, Compressed ——, ... 280
Fuels, Relative Costs of Fluid and Solid ——, ... 120
Fuller, Allen J. Transit Rod, ... 72
Future Water Supply of Philadelphia, Recent Stream Gauging for ——, . . 413

Gas, Pressure and Composition of Natural ——, ... 365
Gauging of Streams for the Future Water Supply of Philadelphia, . . . 413
Gordon, F. W. Lathe for Turning Steel Tired Car Wheels, ... 412
Graff, Frederic. Elected Director, ... 78, 360
Notes upon the Early History of the Employment of Water Power for Supplying the City with Water, and the Building and Rebuilding of the Dam at Fairmount, ... 372
Greathead System of Fire Protection and Public Supply of Hydraulic Power, . 230

Haig, *A. H.* Reproduction of Drawings in Blue Lines on White Ground, . 152
Harbor Studies, ... 285
Harden, J. H. Davis' Self Timing Anemometer, ... 363
Haug, John. William Astor's Steam Yacht, ... 70
Haulage, Relative Cost of —— by Mules and Locomotives, ... 150
Haupt, Prof. L. M. Discussion of Chestnut St. Bridge Repairs, . . 22, 27, 36
Repairs to the Philadelphia Traction Co.'s Conduit, ... 125
Scales of Maps, ... 133
Memorial to Legislature, Second Geological Survey of Pennsylvania, . . 163
Harbor Studies, ... 285
Henderson, G. R. Taper of Steam Jets, ... 384
Hering, Rudolph. Discussion of Chestnut St. Bridge Repairs, ... 30, 35
Elected Director, ... 78, 360
The Early Water Supply of Philadelphia, ... 268
Hoisting Drums, ... 153
Hon. John Bigelow's Report on the Panama Canal, Notes upon ——, . . 416
Hutchinson, E. S. Notes upon the Latitude and Departure Methods of Calculating Areas, ... 83
Notes upon Hon. John Bigelow's Report on the Panama Canal, . . . 416
Hydraulic Power, Public Supply of ——, ... 230

Ice in Delaware River, Movement of ——, ... 385
Included Angle, etc., ... 68
Indicator, ... 69
Ingham, Wm. A. Elected Director, ... 360
Intermittent Siphons, ... 412
Interoceanic Canal Question, Present Situation of the ——, ... 238
Investigation of Movement of Freight and Passengers in Cities, ... 395

Iron Mines, Cornwall, Lebanon Co., Pa., ... 415
Iron R. R. Bridges, Dimensions of ——, ... 204
Iron, Wrought —— Stringers for the Substructure of Railroads, ... 1
Isthmian Transits, ... 48

Jets, Taper of Steam ——, ... 384
Jones, R. W. The Blue Print Process, ... 151
Jones, Washington. Opening Address, ... 194
Compressed Fuel, ... 280
Elected President, ... 360
As to Portrait, ... 364

Land Dredge, Large ——, ... 155
Large Land Dredge, ... 155
Lathes for Turning Steel Tired Car Wheels, ... 412
Lee, H. K. Table of Sizes of Chimneys, ... 411
Lehman, A. E. Model of Cornwall Iron Mines, Lebanon Co., Pa., . . . 415
Lewis, F. H. The Steel Rail Discussion, ... 342
Library, Contribution to ——, ... 89, 170, 422
Lightfoot, Francis. Rail Joint, ... 73
List of Members. See Members.
Literature, Proposed Review of Engineering ——, ... 160
Little Inlet, Sand-Bag Embankment across ——, ... 117
Locomotive Boiler, Coventry ——, ... 268
Locomotives and Mules, Relative Cost of Haulage by ——, ... 150
Locomotives, Fast Passenger ——, ... 97
Lorenz, William. Wrought Iron Stringers for the Substructure of Railroads, . 1
Memorial, ... 55
Ludlow, William. Roe's Surveyors' Tape, ... 76
Elected Director, ... 78, 360

Magnolia, Steam Yacht ——, ... 71
Main Abutment of Chestnut St. Bridge, Strengthening the West ——, . . 14
Maps, Scales of ——, ... 133
Marichal, A. Instrument for Describing Arcs, ... 347
Does Piston Come to Stop at End of Stroke? 406
McCorkle, S. C. Formulæ for Two Sides and Included Angle when Logs. are used instead of Distances, ... 68
Movement of Ice in the Delaware River, ... 395
Meetings, See Minutes.
Members, Additions, ... 92, 95, 283, 284
Resignations, etc., ... 95, 284
Deceased, ... 95, 284
Statements, ... 258, 284
Memorials, William Lorenz, ... 55
Arthur Robert Faunt Le Roy, ... 58
David Hudson Shedaker, ... 61

Dwight Edward Pierce, ... 250
Col. James Worrall, ... 251
Theodore Bergner, ... 403
Merriam, C. A. Mexican National Railway, Photographs, ... 76
Michaelis, O. E. The Keeley Motor, ... 74
Mild Steel, Curious Freak of ——, ... 400
Mills, Fire Protection in ——, ... 70
Minutes of Meetings of the Board of Directors, Oct. 4th, 1884, to April 18th, 1885, both inclusive, ... 85
May 2d, 1885, to July 13th, 1885, both inclusive, ... 167
Nov. 7th, 1885, to March 6th, 1886, both inclusive, ... 363
Minutes of Meetings of the Club, Oct. 18th, 1884, to April 18th, 1885, both incl., 73
May 2d, 1885, to June 20th, 1885, both inclusive, ... 163
Oct. 17th, 1885, to March 20th, 1886, " " 347
Mitchell, S. P. Tables for Finding Ordinates for Circular Arcs, ... 407
Mitis Metal, ... 279
Model of Cornwall Iron Mines, ... 415
Mordecai Gratz. The Investigation of the Movement of Freight and Passengers in Cities, ... 395
Morris, Henry G. Elected Director, ... 78, 360
Copies in Blue Lines on White Ground, ... 350
Movable Dam, ... 273
Movement of Freight and Passengers in Cities, ... 395
Movement of Ice in Delaware River, ... 385
Mules and Locomotives, Relative Cost of Haulage by ——, ... 150
Murphy, Howard. Discussion of Chestnut Street Bridge Repairs, . . . 23, 29
Elected Secretary and Treasurer, ... 78, 360
The Artesian (?) Wells of N. Y. City, ... 155

Name of Club, See Change of Name.
National Public Works. See Civil Engineers' Convention at Cleveland.
Natural Gas, Pressure and Composition of ——, ... 365
New Croton Aqueduct, ... 273
Newell, W. F. The Borup Coal Chute, ... 158
New York City, Artesian (?) Wells of ——, ... 155
New York Entrance, Application of Harbor Studies to ——, ... 300
Nicaragua Ship Canal, Some Engineering Features of ——, ... 327
Nourse, Prof. J. E. Isthmian Transits, ... 362
Novel Cement Testing Machine, ... 194
Novel Rubber and Steel Spring, ... 281

Oestburg, P. Mitis Metal, ... 279
Oil, Pipe Filled with——to Carry Wire to Operate Distant Signal, . . . 341
Old Wernwag Bridge at Philadelphia, ... 156
One Hundred Foot Turntable, ... 73
Opening Address of President Washington Jones, ... 194
Ordinates for Circular Arcs, Table, ... 407

Osborne, Percy T. Engraving of Wernwag Bridge, ... 84
The Sand-Bag Embankment across Little Inlet, Brigantine Beach, N. J., . 117
The Old Wernwag Bridge at Philadelphia, ... 156
Osborne, R. B. Presentation of View of Old Wernwag Bridge at Philadelphia, . 156

Panama Canal, Notes upon Hon. John Bigelow's Report on the ——, . . 416
Passengers, Movement of Freight and —— in Cities, ... 395
Pennsylvania S. V. R. R. Tunnel at Phœnixville, ... 3
Perkins, Samuel C., Esquire. Loan of Description of New York Wells, . . 155
Permanent Tramway in America, The First ——, ... 418
Pertaining to Isthmian Transits, ... 48
Philadelphia, Early Water Power in ——; Fairmount Dam, ... 372
Philadelphia, Recent Stream Gauging for Future Water Supply of ——, . . 413
Philadelphia Traction Co.'s Conduit, Repairs to ——, ... 125
Phœnixville, P. S. V. R. R. Tunnel at ——, ... 3
Pierce, Dwight Edward. Memorial, ... 250
Pipe Filled with Oil to Carry Wire to Operate Distant Signal, ... 341
Piston, Does —— come to Stop at end of Stroke? 406
Planimeter, Amsler's Polar ——, ... 262
Polar Planimeter, Amsler's ——, ... 262
Pollution in Storage Reservoirs, Sources of ——, ... 7
Pollution of the Upper Schuylkill, ... 159
Portable Storage Battery, ... 69
Power, Public Supply of Hydraulic ——, ... 230
Practical Test to Operate a Distant Signal by a Wire Run through a Pipe Filled with Oil, ... 341
Present Situation of the Interoceanic Canal Question, ... 238
President's Annual Address. See Annual Address.
President's Opening Address. See Opening Address.
Pressure and Composition of Natural Gas, ... 365
Print, Blue —— Process, ... 151
Proceedings, Prices of Back Numbers, etc., ... 168
Projection, Stereographic ——, ... 108
Proposed Review of Engineering Literature, ... 160
Public Supply of Hydraulic Power, ... 230
Purification of Sewage, ... 158
Pusey, C. W. Baird's Distiller, ... 363

Questions. No. 1. Upward Current in One of Pair of Shafts, ... 248
No. 2 *a* and *b*. Relative Areas of Pistons and Valves on Blowing Engines, . 249
No. 3. Does a Piston Attached to Crank Come to a Stop at Ends of Stroke? 406

Rail, Steel —— Discussion, ... 342
Railroad Bridges, Dimensions of Iron ——, ... 204
Railroads, Wrought Iron Stringers for the Substructure of ——. 1
Railways, Construction of Steel —— in the U. S., ... 37
Rebuilding a Stand Pipe, ... 72

Recent Specifications as Affecting the Dimensions of Iron R. R. Bridges, . . 204
Recent Stream Gauging for the Future Water Supply of Philadelphia, . . 413
Recording Secretary, See Secretary.
Rectangular Cities, Co-ordinate Method of Ascertaining Distances in ——, . . 148
Reference Book, ... 63, 133, 262, 346, 407
Relative Cost of Haulage, in the Anthracite Mines of Pennsylvania, by Mules and Locomotives, ... 150
Relative Costs of Fluid and Solid Fuels, ... 120
Removing and Rebuilding a Stand Pipe, ... 72
Repairs to the Philadelphia Traction Co.'s Conduit, ... 125
Reports, Annual ——, See Annual Reports.
Reproduction of Drawings in Blue Lines on White Ground, ... 152
Reservoirs, Sources of Pollution in Storage ——, ... 7
Review of Engineering Literature, Proposed ——, ... 160
Ridgway, W. H. Suggestion as to Questions, ... 351
Roberts, A. R. Fastenings for Bridge Floor Timbers, ... 279
Robins, Dr. R. P. The First Permanent Tramway in America, . . . 418
Rock Drill, Beaumont ——, ... 157
Rogers, Fairman. Steam Yacht "Magnolia," 71
Roney, C. Henry. Portable Storage Battery for Mining and Exploring Purposes, 69
Rubber and Steel Spring, ... 281

Sanborn, H. W. Recent Stream Gauging for the Future Water Supply of Philadelphia, ... 413
Sand-Bag Embankment across Little Inlet, ... 117
Scales of Maps, ... 133
Schutte, Louis. Answer to Question No. 1, ... 361
Schuylkill, Pollution of the Upper ——, ... 159
Schuylkill River East Side R. R. Co., ... 102
Second Geological Survey of Pennsylvania, Memorial to Legislature, . . 163
Secretary and Treasurer, Annual Report, See Annual Report.
Sewage, Purification of ——, ... 158
Sewerage Work at Atlantic City, N. J., ... 157
Sheafer, A. W. Relative Cost of Haulage in the Anthracite Mines of Pennsylvania by Mules and Locomotives, ... 150
Shaft, Air Current in ——, ... 248
Shedaker, David Hudson. Memorial, ... 61
Ship Canal, Nicaragua ——, ... 327
Signal, Distant —— Operated by Wire Run through Pipe Filled with Oil, . 341
Simpson, Wm. L. An Indicator, ... 69
Siphon, Behavior of Water in a Double ——, ... 412
Siphons, Intermittent, ... 412
Sizes of Chimneys, Table of ——, ... 411
Smedley, S. L. Reproduction of Hill's Map of Philadelphia, 1796, . . . 73
Smith, W. Bugbee. Fire Protection in Mills, ... 70
Removing and Rebuilding a Stand Pipe, ... 72
Smoking at Meetings, ... 350, 351, 360

Snowden, Robert P. Frogs and Switches, ... 63
Solid and Fluid Fuels, Relative Costs of ——, ... 120
Some Engineering Features of the Nicaragua Ship Canal, ... 327
Sources of Pollution in Storage Reservoirs, ... 7
Specifications, Recent —— as Affecting the Dimensions of Iron R. R. Bridges, . 204
Spring, Rubber and Steel ——, ... 281
Standing Committees of the Board of Directors, See Committees.
Stand Pipe, Removing and Rebuilding a ——, ... 72
Steam Jets, Taper of ——, ... 384
Steam Yacht, Astor's ——, ... 70
Steam Yacht "Magnolia," 71
Steel, Adaptation of —— to Structural Work, ... 197
Steel, Curious Freak of Mild ——, ... 400
Steel and Rubber Spring, ... 281
Steel Rail Discussion, ... 342
Steel Tired Car Wheels, Turning ——, ... 412
Stereographic Projection—Practical Methods, ... 108
Stevenson, A. A. Gas Engine Indicator Cards, ... 76
Storage Battery, Portable ——, ... 69
Storage Reservoirs, Sources of Pollution in ——, ... 7
Stream Gauging for the Future Water Supply of Philadelphia, ... 413
Street Railways, Construction of —— in the United States, ... 37
Strengthening the West Main Abutment of Chestnut St. Bridge, ... 14
Stringers, Wrought Iron —— for the Substructure of Railroads, ... 1
Strong, Geo. S. Recent Locomotive Construction, ... 83
Rack Rail Appliances for Railroads, ... 350
Structural Work, Adaptation of Steel to ——, ... 197
Substructure of Railroads, Wrought Iron Stringers for the ——, ... 1
Switches, Frogs and ——, ... 63

Taper of Steam Jets, ... 384
Tay Bridge, ... 281
Testing Machine, A Novel Cement ——, ... 194
Thompson, C. T. Description of the Construction and Manner of Turning of the Large Hoisting Drums of the Calumet and Hecla Mining Co., . . 153
Titlow, J. Milton. Strengthening the West Main Abutment of Chestnut St. Bridge, ... 14
Discussion of ditto, ... 25
Traction Co.'s Conduit, Repairs to the Philadelphia ——, ... 125
Tramway, The First Permanent —— in America, ... 418
Transit Rod, ... 72
Transits, Pertaining to Isthmian ——, ... 48
Trautwine, John C., Jr. A One Hundred Foot Turntable 73
Large Land Dredge, ... 155
Treasurer, See Secretary and——.
Trigonometrical Formulæ, ... 68
Tunnel, P. S. V. R. R. ——, at Phœnixville, ... 3

Turning of Large Hoisting Drums, ... 153
Turning Steel Tired Car Wheels, Lathes for——, ... 412
Turntable, One Hundred Feet——, ... 73
Two Sides and Included Angle, etc., ... 68
Tyson, A. Harvey. Sources of Pollution in Storage Reservoirs, ... 7

Van Harlingen, M. The Penna. Sch. Valley R. R. Tunnel, at Phœnixville, . 3
Vezin, Henry A. Mining Methods in Colorado, ... 79
Diagrams for Determining Belts, Pulleys and Shafts, ... 80
Diagrams for Cast Iron Cogs, ... 80

Waddell, Prof. J. A. L. A Proposed Review of Engineering Literature, . . 160
Wagner, S. T. A Curious Freak of Mild Steel, ... 400
Water Power in Philadelphia, Early ——, ... 372
Water Supply of Philadelphia, Early ——, ... 268, 372
Water Supply of Philadelphia, Recent Stream Gauging for ——, . . . 413
Water Works of Columbus, Ga., ... 52
Wells, Artesian (?) —— of N. Y. City, ... 155
Wernwag Bridge, Old —— at Philadelphia. 156
West Main Abutment of Chestnut St. Bridge, Strengthening the ——, . . 14
West, Preston C. F. Pertaining to Isthmian Transits, ... 48
Wharton, William, Jr. The Construction of Street Railways in the U. S., . . 37
Williamson, T. Roney. Thanks to —— for Architectural Services, . . 347, 349
Wire, Run through Pipe Filled with Oil, Operating Distant Signal, . . . 341
Wister, Jones. The Beaumont Rock Drill, ... 157
Wood, James F. Sewerage Work at Atlantic City, N. J., ... 157, 363
Wood, John, Jr. An Automatic Car Coupler, ... 156
Worrall, Col. James. Memorial, ... 251
Wrought Iron Stringers for the Substructure of Railroads, ... 1

Yacht, Astor's Steam ——, ... 70
Yacht, Steam —— "Magnolia," 71
Yocum, Jacob H. The Water Works of Columbus, Ga., ... 52

ILLUSTRATIONS.

PLATES.

Chestnut St. Bridge, Plan and Elevation, ... facing page 14
" " " West Main Abutment, ... " " 18
Section of Rails for Street Railways, ... " " 46
Water Works of Columbus, Ga., ... " " 52
Fast Passenger Locomotive, ... " " 97
Schuylkill River East Side R. R. and other Railroads in Philadelphia, ... " " 107
Stereographic Projection, ... " " 116
Sand Bag Embankment across Little Inlet, Brigantine Beach, N. J., " 118, 119
Repairs to the Philadelphia Traction Co.'s Conduit, ... " " 127
President J. J. de Kinder, Portrait, ... " " 173
Novel Cement Testing Machine, ... " " 195
Brick Arches, ... 213, 215, 216
Harbor Studies, ... 303, 305, 310, 317
Nicaragua Ship Canal, ... 340

FIGURES.

Chestnut St. Bridge, Cylindrical Buttress, ... 19
" " " Air Lock, ... 20
Frogs and Switches, ... 63, 65, 66
Case in Trigonometry, ... 68
Stereographic Projection, ... 112, 113, 114, 115
Movable Dam, ... 275, 276, 277

PROCEEDINGS

OF THE

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I.

WROUGHT IRON STRINGERS FOR THE SUBSTRUCTURE OF RAILROADS.

By WILLIAM LORENZ, Member of the Club.

Read February 2d, 1884.

The following were but preliminary notes, the illness and subsequent decease of the author having prevented the completion of the paper and the preparation of its illustrations.—*Sec.*

To construct a railroad track with longitudinal stringers satisfactorily, it is absolutely necessary that the splices at all the joints have the same amount of resistance as the rails and stringers themselves; there must be no more deflection at the joints than at any other point of the track.

In the "Hilf" system the joints were always bad; the long stringer or "gravel trunk" was always uneven, giving either too much or too little resistance. For that reason the cross-ties were entirely omitted at the joints, and the rails and stringers were spliced at the same point, because, on account of the shape of the stringer, the rail splice would not be made strong enough, but the stringer splice could be constructed with such additional strength as to compensate the defect in the rail joint.

The "Haarman" system of long stringers, with clamp fastenings, was adopted by the City Railroad of Berlin, because the box-like shape of the stringer admitted of a deep rail splice, giving at

the joint the same strength as the rail itself has, so that the stringer splice has only to maintain the uniform strength of the stringer itself, without the excessive strength, as in the "Hilf" system. (These splices must be at least 60 cm. long, and must have four bolts.) On account of this uniform strength of the "Haarman" system, the grading and the ballast settle evenly under the stringer, giving a uniformly elastic track, although somewhat more solid than a track with cross-ties. The width of the stringer (32 cm.) was determined by the local condition of the road-bed and the nature of the ballast (Hilf makes his only 30 cm.); the height of rail and stringer together is about 20 cm. The cross-ties are placed under the stringer, and must have very little surface, so that they may readily press into the ballast, their only object being to maintain the gauge. The good results of this system depend almost entirely upon the good condition of the road-bed. On first-class railroads, with a well settled road-bed and stone ballast, and with the stringer or trunk well filled with gravel, there is no trouble whatever to keep the rails in position and maintain the gauge. On sharp curves it is, however, necessary to put tie-rods through the rails. The horizontal pressure on curves of the front wheel of a locomotive with three pair of driving-wheels, is about $\frac{2}{5}$ of the weight upon the wheel. This pressure naturally compresses the ballast on the outside of the stringer more than on the inside, and thereby spreads the gauge, an evil that any amount of strength in the cross-tie under the stringer would not overcome, so that, if objections are made to tie-rods between the rails, the only remaining remedy is to put them through the trunk as high up as possible. In spite of these objections, the managers of railroads, especially those of Berlin and Hanover, are very much pleased with the "Haarman" system. When the road-bed is perfectly settled, there will be but little trouble even at curves. This is, however, rarely the case, and the mere tamping of fresh ballast under the stringer will not prevent the spreading of the track; for that reason it would be advisable when the track is first laid to make the gauge somewhat tight, and raise the outer rail a little higher, so that after settlement takes place, everything will be in the proper place. The clamp fastenings are very good, but care must be taken not

to draw them too tight, so as to make the rail and stringer one solid beam, which would be too rigid and very apt to break.

It is important that the surface ballast should be gravel, broken stone would not pack solid enough in the stringer, but under the gravel a well-rolled bed of broken stone would insure still more permanency; outside of the track the ballast should be filled up to the top of the rail, and at least to the height of the foot of it on the inside.

On account of the heavy pressure, the ballast under the stringers is likely to become so solid as to be impervious to water, and some difficulty in draining is likely to be encountered. Unless some material like furnace-cinder can be found, that will always permit the passage of water, cross-drains of pipes would have to be placed at regular intervals under the stringers from the centre of the track.

II.

THE PENNSYLVANIA SCHUYLKILL VALLEY RAILROAD TUNNEL AT PHŒNIXVILLE.

By M. Van Harlingen, Member of the Club.

Read February 7th, 1885.

Tunneling may be considered to be a branch of business by itself, but at the present time all civil engineers are supposed to know something of this branch of their profession; this being understood, it is not necessary for me to go into the history of tunneling, as the object of this essay is to give a short description of the one lately built near Phœnixville on the Schuylkill Division of the Pennsylvania Railroad.

This tunnel is cut through a ridge of hills which runs nearly parallel with the Schuylkill River, and is in the same hill through which the old Phœnixville Tunnel was cut by the Reading Railroad in 1835–1837, and enlarged for double track in 1858–1859, the new tunnel being nearly at right angles to the direction of the original one, but about half a mile further west.

In order to make this tunnel as short as possible, advantage was taken of depressions on each side of the hill, by which means the approaches as well as the tunnel itself was shortened.

Work was begun on the approaches in February, 1883, and pushed with vigor, there being 71,614 cubic yards of material to be moved before the headings could be started. This material was taken out in benches, as many as five at each end being in operation at one time. Eight foremen, 151 men, and 36 horses, being the average force engaged upon this work.

Towards the first day of June it was determined to sink at once for a heading, the subject of sinking a shaft being abandoned, for the reason that the time required for this could be more profitably employed in sinking at the portals, so that work could be pushed in the headings at the same time the approaches are being taken out.

By this means work at the south heading was started June 20th, 1883, and at the north heading August 5th, or about the time it was estimated a shaft could be sunk to the level of the heading.

Work in these headings was pushed so rapidly that by the time the approaches were out the headings had met, or, in other words, by the 12th of August, everything was ready to begin work taking out the full section of the tunnel.

The headings were holed in 120 working days, the average daily progress being 6 ft., the total cubic yards of material moved in this time being 4,681, or about 39 cubic yards per day, at an estimated cost of $5.25 per cubic yard. The number of men employed in the headings averaged 45 per day, or 28 miners and 17 muckers or laborers. The work was all done by hand drilling, steam drilling being abandoned after the first day or two. Two shifts of eleven hours each was found to be the most economical, as less time was lost in changing, the men at work having an hour's rest at noon and at midnight.

The temporary timbers of the headings were set so as not to interfere with the timbers that were afterwards to be put in, when the full section should be taken out, many of these timbers remaining in the tunnel, as it would have been dangerous to have removed them on account of the loose material in the roof of the tunnel. Both the temporary and the permanent timbers were so placed as just to clear the brick arching, and so successfully was it done that in but one or two instances was it necessary to cut away any of the timber to allow the keying of the arch.

The ventilation of the heading was obtained at the north end by means of a tin tube about the size of an ordinary rain conductor, say 4 in. or 5 in. diameter, into the lower end of which a jet of steam was passed, causing an upward current of air and indrawing the foul air from the heading, which was replaced by outside air by the circulation thus caused. At the south end a wooden trunk was used, the section of which was 6 in. × 10 in., steam entering in the same way as at the north end. This was not a very satisfactory way of ventilation, but it answered the purpose; as the air, though close to a person coming in from the outside, did not seem to inconvenience the men at work, and as it took but a short time to clear the air sufficiently after a blast to allow the men to go to work again, nothing further was attempted.

At first it was supposed that the only trouble we might expect would be from the roof, and that the sides would be of sufficient uniformity to stand at the slight inclination below the foot of the heading timbers, but before we had gone far, it was found that we would have to timber to the springing line, for that purpose and with a view of perhaps using the tunnel temporarily to take the material for track laying through to the work beyond, which was rapidly reaching completion, it was determined to use what is known as the American or self-supporting style, made like a wooden arch of 12×12 stuff in lengths of 4 ft.

This was deemed the best adapted for the kind of material we had to go through, as was demonstrated by what had been met in the approaches and also in the heading, which is composed of layers of soft and hard red shale, with a few ledges of yellowish brown sandstone, all of which showed fissures and cracks with an inclination of about 10° in the direction of the tunnel, and about 4° to 6° across the face. None of the material was of a nature that could be depended upon to keep a vertical position when exposed to the action of the air.

The benches in the tunnel were started November 12th, 1883, at both ends, and were entirely removed by March 7th, or in about 117 working days. The total number of cubic yards moved was 17,011. The daily progress was 7 ft., or $145\frac{4}{10}$ cubic yards were moved on the average each day. The daily force

was 153 men, including foremen, miners, muckers and nippers. There were beside 7 horses, 2 small locomotives and 15 dump cars. The average cost of removing this material was $2.50 per cubic yard.

As soon as the full section was advanced sufficiently so as to make it safe to begin with the masonry, which was about the middle of December, 1883, the footings or side walls were begun at each end, the masonry being put in in sections of 25 ft. at a time to allow for setting before the arch was started, the masonry being kept about 100 ft. in advance of the brickwork.

The arching was put in in sections of 20 ft., it taking about two days to set and pack a section, working day and night.

The stone masonry for the side walls was started December 18th, 1883, at the south end, and on January 4th, 1884, at the north end, and completed March 25th, 1884, or in 82 working days. There are 886 cubic yards of masonry in these side walls, giving an average of $10\frac{8}{10}$ cubic yards as a day's work for 5 masons and 10 laborers.

The brick arching was begun on the south end January 4th, 1884, and at the north end January 14th, and completed or pigeon-holed April 12th, making 86 working days. The total number of cubic yards of brickwork was 2,696, giving an average of 31.35 cubic yards as a day's work for 2 foremen, 9 bricklayers and 40 laborers. Some of the latter were engaged in packing the arch as it progressed with the materials taken from the tunnel, so as to distribute the weight evenly over the haunches of the arch and to leave no vacancies between the timbers, so that as they decayed the pressure should come early as possible, and by degrees upon all parts of the arch. The packing was done at night while the bricklayers were not at work, it taking nearly as much time to pack as it did to lay the brick in the sections. About 3,600 barrels of cement and 1,400,000 bricks were used in arching this tunnel.

The façades were the last thing finished and proportionately the longest in being done, having been begun April 12th, and not finished till May 3d, 1884, not quite $16\frac{1}{4}$ cubic yards being the average day's work for 7 masons and 15 laborers.

The stone cutting on the façades equaled 475 days work for one man.

Total length of tunnel excavated,		800 ft.
The south façade projects, . .	7 ft. 9 in.	
" north " " . .	7 " 0 "	14 ft. 9 in.
Total length at springing line, ...		814 ft. 9 in.
" " between faces of keystone, . .		809 " 9 "
Clear width at springing line, ...		27 " 0 "
" height above top of rail, ...		19 " 10 "
Total excavation in tunnel, ...		22,807 cub. yds.
" " per lineal foot, . . .		$28\frac{5}{10}$ "
" masonry, ...		3,891 "

As follows:

In façade, . .	308 cub. yds.	= $20\frac{53}{100}$	cub. yds. per lin. ft.
" side walls, . .	887 "	= $1\frac{11}{100}$	" " "
" brick arching, .	2,696 "	= $3\frac{37}{100}$	" " "

The cost of the tunnel was	$119,899.50
" " per lineal foot, including façades, . .	147.16
Excavation cost, ...	$97.97 per lin. ft.
Side walls "	9.11 " "
Brick arching "	35.92 " "
The façades added . . . . . to the total cost of the tunnel.	4.16 " "

III.

SOURCES OF POLLUTION IN STORAGE RESERVOIRS.

By A. Harvey Tyson, Member of the Club.

Read February 7th, 1885.

Since the subject of water supply for cities not only involves advantages for domestic uses, fire protection and manufacturing purposes, but also the sanitary condition of communities, the subject of purification becomes a serious problem, and one which demands the immediate attention of municipal authorities and those persons engaged in the business of serving this necessity which is constantly performing some of the most important func-

tions of nature and the physical purposes of life. Man is so constituted that he requires large quantities of water to obtain the blessings of health and civilization, and unless the water used is practically pure, the thing intended to aid him to the full enjoyment of life becomes an obstacle to its attainment.

As City Engineer of the City of Reading, my experience concerning the subject of this paper is gathered from my connection with its Water Works. Previous to the year 1880, during which the Antietam Lake, with a storage capacity of ninety millions of gallons, was constructed, the supply of the town was small. Citizens were satisfied with water of any kind—it was not a matter of quality, but of quantity. There was an occasional grumble about the condition of the water served consumers, but in a few days the impurities would disappear, and the state of public opinion would return to its normal condition. During the construction of the dam named, there was quite a perceptible increase in the impurity, as the water had a woody taste and when left standing for five hours or more emitted a very disagreeable odor. This was attributed to the fact that the banks of the streams passing through the dam, and the flows of which were to be impounded, had been cleaned and grubbed. The bad taste and odor lasted for three weeks and then ceased. About the first of August of the next year it again presented itself; this time in a worse form, the odor remaining the same, but the taste had changed, and resembled that of fish oil. The suggestion was made that there was a deposit of filth in the pipes, and with a view of removing such, if it was the cause, flush valves were placed in all depressions in the pipes and at the dead ends, and these, as well as the fire hydrants, were periodically opened. This did not remove the difficulty and improve the water. The parts of the city served directly from this storage reservoir were the only ones in which this impurity was noticed. Those served from the distributing basins showed no signs of it. The entry into the latter was through fountains which threw the water to a height of seventy-five feet, thereby thoroughly oxidizing it and removing the impurities. An examination into the cause of the trouble showed that instead of having the natural blue-green color, it had a bright green, and when left standing the impurity

came to the surface and discolored it. Whenever during the ten weeks during which the odor and taste remained the thermometer for more than a day fell to below sixty-five or seventy degrees Fahrenheit, the impurity disappeared, to return again, when the temperature exceeded seventy or seventy-five degrees. An examination of the lake developed the cause of the trouble to be a vegetable formation, which when alive and scattered through the water gave no noticeable taste or odor to the water; but in its decay became highly offensive. As to what this vegetable formation was, the botanists differed. My conclusion, on a microscopic examination was that the growth was of minute confervoid algæ, whose germ was the clorophyl, or coloring matter of leaves. The plant itself when gathered from the surface seemed to be without disagreeable taste or odor, but when exposed to the heat and light of the sun rapidly fermented and became very offensive. This plant when in subsiding reservoirs subject to the sun's rays grows rapidly, and when drawn into the distributing pipes, the want of air causes decay, and as a result, *taint.*

With each succeeding year, the trouble has returned, grows worse and remains longer. Nor is it local in its development; but the result of correspondence with over one hundred towns and cities where water is impounded, shows that the trouble has shown itself in a more or less degree everywhere, and how to avert and correct it, has been the problem worrying the Hydraulic Engineers. Numerous plans have been proposed, from oxidation by flow through open channels or artificial æration, to the gigantic scheme of roofing in the reservoirs to remove the effect of heat and light and so remove the cause of the development of this new but unpleasant affinity. Future experiment will demonstrate the most feasible plan,—but from my experience I would say that natural æration is the best, for the reason that the water in our small distributing reservoirs which enters through the fountains as stated above, has always been pure.

The trouble is comparatively modern. Ponds and sluggishly moving streams which were sweet twenty years ago as I loitered along them, are now affected in a like way, without any change of conditions. They are affected by the climatic change which the country is undergoing. Steady rains have ceased and the precipitation is sudden and rapid.

Chemical analyses of our water affected, have shown that there is nothing deleterious to public health, although it may be exceedingly disagreeable. Examinations for the last three years resulted as follows:

	1882.	1883.	1884.
Free Ammonia	.0028	.0027	.0035
Albuminoid "	.0175	.0175	.0133
Chlorine	.2900	.2950	.3000

And with the increase of pollution from this source there has been a corresponding decrease in the death-rate, which, from the records of the Board of Health, is as follows:

1880, 20.1 per M.; 1881, 21.0 per M. (Scarlet fever epidemic); 1882, 20.0 per M.; 1883, 19.0 per M.; 1884, 18.9 per M.

The facts as stated above, that this source of pollution is not deleterious to public health should not allow Engineers and local authorities, by an appeal to the purse, to let it pass by without some determined effort at correction, as it may tend to the development of some characteristic which would be damaging.

DISCUSSION.

By Mr. Charles G. Darrach.

Data collected during the past seven years disproves the old theory that, as an approximation, we may estimate a daily average yield of 1,000,000 U. S. gallons (133,370 cubic feet), per day, per annum, per square mile of catchment area, or the utilization of 23 inches of rainfall. In fact but one-half this amount should be estimated.* We are therefore forced to increase the storage ca-

* The following table gives the results of the measured yield from streams supplying the cities of New York and Boston, during the driest year on record, viz.: 1880.

Name of Stream.	City Supplied.	Drainage Area.	Period of obs.	Minimum Year, 1880.			Average Daily Flow. Million of Gallons.	
		Sq. Miles.	Years.	Inches of Rain.	Inches of Loss	Inches of Flow.	From the total area.	Per sq. m.
Croton, .	New York	338.82	18	37.16	21.96	15.20	246.0	.725
Sunbury .	Boston .	78.00	9	38.18	25.67	12.49	46.3	.594
Mystic .	"	27.00	8	44.42	22.14	12.28	15.7	.582
Cochituate	"	18.67	32	35.83	25.53	10.80	9.1	.487

Also see Annual Report of the Department of City Works, Brooklyn, N. Y., 1880; Engineering News, April 3d, 1880, page 122; Report of Tenth Census of U. S.; "Statistics of Power and Machinery employed in the United States," pp. 17 and 21.

pacity, to tide over dry years, calculating the average yield of 24 or 36 months instead of 12 months; in so doing, the depth of the collecting storage reservoir is increased, and it is to this point your attention is directed.

In 1875 I noticed that the water drawn from a depth of 50 feet, in Tumbling Run Dam, was very offensive in odor; but after contact with the air the water became odorless and potable, similar to the water on the surface of the Dam.*

In the winter and spring of 1881, the City of Baltimore suffered from bad water; various theories were suggested, and if my memory serves me, the bad water was drawn into the service from the distribution pipes and from the bottom of the reservoirs.

In 1882 I visited the Baltimore Water Works, and became convinced that one, if not *the* cause of trouble was *deep* reservoirs. After a comparison of notes with Mr. Robert K. Martin, Chief Engineer, he determined to experiment, as follows:

Waste all *surplus* water from the *bottom* of the reservoirs on the Gunpowder supply, and allow the Jones' Falls surplus to waste over the wiers.

The following data will give a basis of comparison:

Druid Hill Reservoir: Storing and distributing reservoir for Jones' Falls supply; maximum depth, 65 feet; capacity, 495,000,000 U. S. gallons; daily consumption, 10,000,000 U. S. gallons. The inlets to the reservoir are two, one at the upper end and the other about the middle of the reservoir, both of them discharge into the reservoir at the bottom.

The outlets are at the lower end of the reservoir, ¾ of a mile from the upper end, and at three levels, viz.: 15, 26 and 39 feet below the surface.

Lake Montebello: The receiving reservoir of the Gunpowder supply is 30 feet deep. All the other reservoirs 20 feet deep.

In 1881 a difference of 10 degrees to 12 degrees Fahrenheit was noted between the temperature of the surface water and water at a depth of 50 feet, in Druid Hill Reservoir.

In the latter part of November and in December, 1882, and in January and February, 1883, the water supplied from Druid Hill

* Tumbling Run Dam is one of the feeders of the Schuylkill Canal; its drainage area is well wooded and not subject to artificial pollution.

Reservoir (Jones' Falls supply) again was bad, while that from the Gunpowder supply was good.

In a letter dated Jan. 8th, 1883, Mr. Martin writes to me as follows: "We have had bad water from our Jones' Falls supply for two months. The big supply from the Gunpowder has been very good. Don't know whether wasting at the bottom of the storage and receiving reservoirs has kept it from being bad or not, it nevertheless is very good."

Feb. 1st, 1883, Mr. Martin writes: "The only place we had bad water was in Druid Lake, 50 feet down from the surface, while the surface was good. And this is the only basin that a flow or waste from the bottom had not been kept up right along since last summer.

"Those basins where this flow has been kept up the water is and has been very good. As soon as I found the water bad I commenced to waste from the bottom, and in a short time the water was much better, and now is pretty good. Time alone will prove whether wasting at the bottom is the thing to continue; so far, it has done good."

February 16th, Mr. Martin writes, in answer to questions: "I found the water in Druid Lake good at 5, 10 and 15 feet below the surface, but bad below that. The water was bad at the flow line to the City main. The water was drawn off at a point 30 feet below the flow line to the City mains. I think the accumulated bad water below the flow line had a tendency to impair the quality of the water above it."

March 8th, Mr. Martin writes: "The water in Druid Lake has got all right again, we have no bad water in any of our lakes or reservoirs."

In the paper before us it is stated that while the water drawn from the pipes leading from the collecting and storage reservoirs was bad, it improved after being discharged into the distributing basins.

Mr. C. S. d'Invilliers, Member of the Club, informs me that it is his impression that the collecting reservoir for the City of Reading (that mentioned in the paper), is about 40 feet deep, and that its capacity is great compared with its catchment area. I do not remember the data of the completion of this reservoir, nor the

length of time the water has been stored. It is probably two or three years. Light would be thrown on the subject did we have before us all the data as well as the plans of the reservoir.

From the data furnished by Mr. Martin, the water in Druid Lake seems to have fouled in two years, from 1881 to 1883.

A theory which these facts seem to indicate is, that products of *decaying* vegetation sink to the lower water in deep reservoirs, where decomposition is suspended for want of oxygen; the gases are absorbed by the water, which upon contact with the air are fully oxydized.

As a prevention, surplus water should be wasted from the *bottom* of the deep reservoir, and not over the weirs. As a cure, *aëration*, by means of shallow distributing reservoirs, receiving the water on the surface, and if possible from fountains.

In 1881 the newspapers of Baltimore stated that as chemists had failed to discover impurities, after testing the water which caused complaint, Dame Nature probably forestalled them.

I would in this connection, call attention to the fact that in the proposed Quaker Bridge Dam for the New Croton Aqueduct, no provision seems to have been made, as far as can be learned from published plans, for drawing off the water from the lower levels. As this dam will be of almost unprecedented depth, the same trouble may be expected as in Baltimore and Reading unless this precaution is taken.

Instead of gates at the bottom of deep reservoirs, syphons could be used to advantage, not only in new work, but in reservoirs where no provision has been made for drawing off the water. The syphon weir has the advantage of being automatic, and can be arranged to draw off the lower levels during floods, when the fresh water would otherwise flow to waste.

Dr. H. M. Chance

was of the opinion that in the great fresh water lakes we had conditions analogous to those present in artificial storage reservoirs, and therefore asked if any member could tell whether any examinations had been made into the condition of the water at considerable depths. If this was found to be fresh and of good quality—similar, in other words, to the water near the surface

of these lakes, then an inquiry into the conditions which protected it from contamination, or purified it, would be of great value; but if, on the other hand, the water at great depth was found contaminated in the same way as that in storage reservoirs, then it would be useless to look for any natural phenomena to assist in purifying stored water, and reliance must be placed upon some artificial method. He believed the subject was of sufficient importance to warrant an immediate investigation into the character of the deep water of these great lakes, and thought that until this was done sanitary engineers, in declining to avail themselves of this knowledge of natural laws, were committing a great mistake, and were necessarily working in the dark.

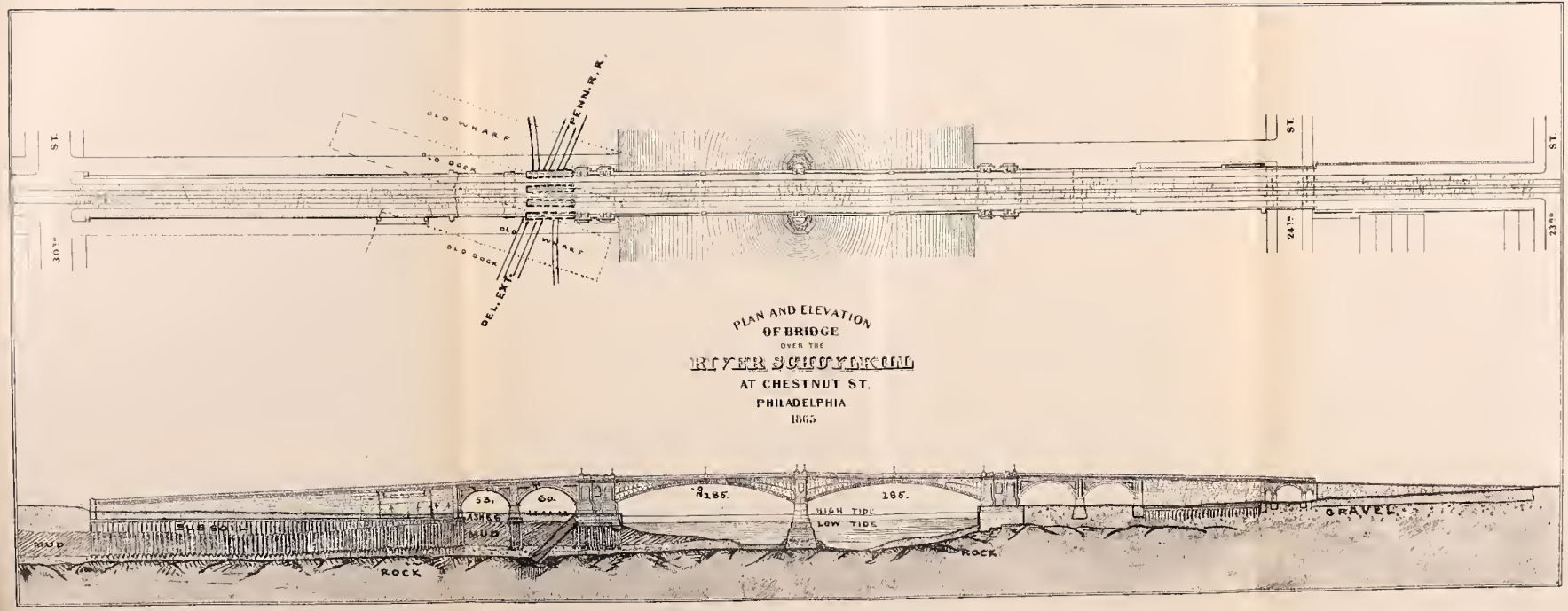
IV.

STRENGTHENING THE WEST MAIN ABUTMENT OF CHESTNUT STREET BRIDGE.

By J. Milton Titlow, Member of the Club.

Read February 21st, 1885.

The Chestnut Street Bridge, in the City of Philadelphia, is used for highway purposes, and with its approaches is 1,528½ ft. in length, extending from Twenty-fourth Street on the east to Thirtieth Street on the west. It is 42 ft. in width between railings, and has two cast iron main spans across the Schuylkill River of 185 ft. each with 20 ft. rise. The river pier is 16 ft. in thickness at springing line, and each of the main abutments on the shores 42 ft., 2 in. In the rear of each of these abutments, east and west, are two segmental brick arches 2½ ft. in thickness, designed of 60 and 53 ft. span; east of these spans are parallel rubble retaining walls extending to Twenty-fourth Street, where there is a 26 ft. arched span over the roadway and two 7 ft. arches over the footways. On the west are also parallel rubble retaining walls extending to Thirtieth Street, holding the embankment, or filling supporting the roadway formation.


PLAN AND ELEVATION
OF BRIDGE
OVER THE
RIVER SCHUYLKILL
AT CHESTNUT ST.
PHILADELPHIA
1865
PENN. R. R.
OLD WHARF
OLD DOCK
DEL. EXT.
ST.
30TH
24TH
23RD
53.
60.
185.
185.
HIGH TIDE
LOW TIDE
ASHES
MUD
ROCK
GRAVEL

The elevation above city datum, which is about 2 ft. below the top of the present wharves of the roadway at river pier, is +39.; at Twenty-third Street +17., and at Thirtieth Street +15., making grades rising onto the main spans of 4 to 2 ft. per hundred. The surface of rock at east main abutment is —21.; at river pier —37.; at west main abutment —47., and about the same level westward to Thirtieth Street. The river pier by means of a wooden crib rests on the rock; the east main abutment directly on the rock, and the part of the approach to the eastward on the gravel and short piles.

The west approach is located upon what was called the river flats, partly occupied by wharves and docks, with a strata of river mud or silt from 16 to 20 ft. in thickness upon a strata of coarse gravel, with cobble stones and boulders overlaying the bed rock, the surface of which from the elevations given above, show slopes to the westward and is almost horizontal north and south. The whole of this part of the structure rests upon piles which increase in length from 24 ft. at main abutment to 40 ft. at Thirtieth Street; those under the main abutment, 397 in number, were driven through the mud and into the coarse gravel with a 1200 lb. hammer to three-quarter inch penetration and 20 ft. fall, and it now shows no signs of any vertical movement having taken place. The mud was excavated around the pile-heads $2\frac{1}{2}$ ft. in depth; this space and also that between the 12×12 in. oak caps to the close deck of 12×12 in. hemlock was filled with concrete; the timber now appears to be in as good condition as when originally placed in position.

The retaining walls on the west side were built of rubble masonry, and proportioned three-tenths their height at one-third from the platforms with a batter of one-tenth on the face. The platforms and piling form two separate lines of foundation. The space between the walls was filled with earth, gravel, etc.

A general description of the masonry and foundations may be found in the *Franklin Institute Journal*, of June, 1865, containing a paper read by the late Strickland Kneass, the chief engineer.

The bridge was completed in October, 1867, and cost $500,000. This was considered at that time a large amount to expend on a public work of this kind, and the engineer was restricted in

many ways by City Councils; and soon after the bridge was completed the public began to demand two of the things he very much desired: wider approaches and easier grades.

During the filling of the space between the west approach retaining walls, the south wall where it crossed an old dock, moved so much that it was taken down and increased in thickness, forming a buttress at that point 55 ft. long. It is probable that both walls moved outward at that time and appear to have continued more or less; the north wall particularly, as shown by the line of the railings which were erected in the spring of 1866. Near where this north wall intersects a former dock, the top of it for 150 ft. in length has possibly moved northward $1\frac{1}{2}$ in. in the last ten years.

A few years after the completion of the bridge, the abutment of the 53 ft. span began to show signs of weakness by moving back at the springing line; that is concave, with a separation of the vertical joints from the surface of the ground to the skewback, where the opening is $1\frac{1}{2}$ in. wide, and continuing upward and running out about one-third the length of the adjoining arch. At this vertical crack, or $18\frac{1}{2}$ ft. from the north end of the abutment, the face leans west 4 in. in 7 ft. vertical, and is 5 in. back of a straight line, joining the ends of abutment at springing line. This concavity, as well as the separation of the vertical joints, disappears toward the platform, which is apparently on the face solid and straight. The ends of this abutment lean 2 in. west in 7 ft. vertical, a somewhat greater rate of inclination than their buttresses, which lean 6 to 7 in. west in 28 ft. vertical. The face of this abutment has apparently not changed in the last twelve years.

The span of this 53 ft. arch at crack and springing line is 52.97 ft.; at the north side $\frac{32}{100}$, and at the south side $\frac{43}{100}$ of a foot shorter. The other span to the eastward and in the rear of the main abutment, at the springing line and north side, 59.96, and south side, 60.0; it is about one inch less at the water-table, caused by the pier leaning west three-quarters of an inch in 7 ft. vertical. The west main abutment shows no great variation from being vertical, and to the general observer apparently as built. The river pier leans $2\frac{1}{2}$ in. west in 27 ft. vertical.

The masonry was practically completed in 1865, about a year before the cast iron river spans; and any movement of the main abutment, by reason of it maintaining its verticality, transferred a horizontal thrust to and through that part of the approach in the rear. That a westward movement has taken place is shown by the depression of the crowns of both river spans; the closing of the joints of copings on spandrel walls from main abutment to about 50 ft. on the retaining walls; the rising of the crowns of both approach arches, as well as pushing back the small approach abutment at the springing line between the retaining walls; the condition of which has been described above.

The rising of the west arch became very apparent during 1879, and in November of that year horizontal wooden struts, with a solid 3 in. platform under those in the 60 ft. span, were placed above the platforms of foundations at high water level between the main abutment and the west abutment, opposite the retaining walls, for the purpose of taking up and transferring this horizontal thrust to them and making them act as buttresses temporarily until a plan could be determined upon which would be effective in itself. Four wrought iron tie rods were passed transversely through the filling and retaining walls in the rear as a precaution against their further bulging.

The horizontal thrust of the cast iron river spans from dead load is 1,840 tons, and including 70 lbs. per square foot live load 2,000 tons. The lines of maximum pressure of this span and the adjoining arch are shown by the dotted lines. The horizontal thrust of the 53 ft. approach arch is 500 tons, and the pressure line of that arch is shown through its abutment; if this horizontal thrust is increased 600 tons it will throw this line out of the back of the abutment at the springing line.

It was evident that the place on shore to take up this thrust was in the rear of the west main abutment, and under the 60 ft. span, which is occupied by the double tracks of the Delaware Extension of the Pennsylvania Railroad and two sidings. To shift these tracks westward to the other arch would occasion not only delay in getting the proposed work under way, by reason of occupying private property, but would have damaged the lessees

in facilities, loss of business, etc., probably equal to one-half the cost of the intended work.

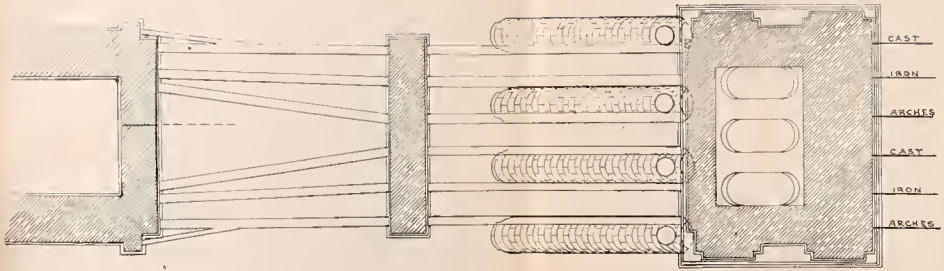
A variety of plans were proposed to accomplish the object; the majority of which to act as buttresses, had the objection of the difficulty of execution to reach the rock in the contracted space at our disposal, without disturbing the apparent equilibrium of the structure by the removal of great quantities of material in the rear of the main abutment; and also the necessity for removal of one or both of the main railroad tracks.

Of the several designs suggested for cylindrical iron buttresses, that of Mr. J. F. Anderson was adopted; having the great advantage of facility of construction in the limited area not occupied by the railroad tracks, and the immediate filling the space occupied by the materials removed. The manner of reaching the rock being the same as that used on the pilot of the Hudson River tunnel, except that instead of being horizontal and advancing directly forward, as in that case, the cylinder is inclined and advanced downward.

This design, as executed, consisted of placing, by means of compressed air, four wrought iron cylindrical buttresses, 8 ft. in diameter, filled with concrete, inclined at 45 degrees from a horizontal and parallel with the axis of bridge, about 62 ft. in length, extending from the rear of the west main abutment at the platform to the bed rock. They are 6 and 8 ft. apart and almost directly in line with the division walls of the cells in the abutment, and were so spaced that the wooden struts should not be cut off.

As the strata of coarse gravel overlaying the rock was subsequently found to contain large cobble stones and boulders, it is believed that the pneumatic process is the only one by which the rock could be satisfactorily reached and steps excavated into it, having beside the great advantage of seeing exactly what was being done and having the work at all times under complete control.

Each cylinder is made up of half-inch wrought iron plates, 2 ft. by about 3 ft. in size, the joints being parallel and square with its axis. They are connected by $3\frac{1}{2}$ in. angle bars, rivetted around the edges of the plates and bolted together when in position, forming rings 2 ft. in length and breaking longitudinal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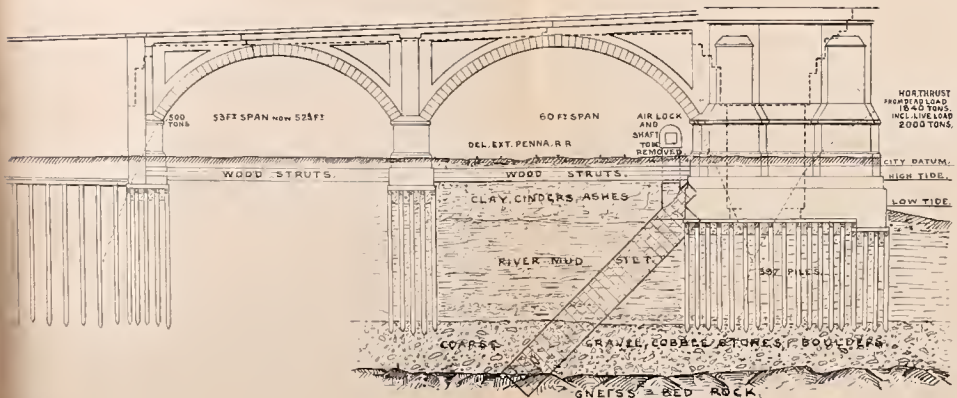

500 TONS
53 FT SPAN NOW 52½ FT
60 FT SPAN
AIR LOCK AND SHAFT TOW REMOVED
DEL. EXT. PENNA. R R
WOOD STRUTS.
WOOD STRUTS.
CLAY, CINDERS, ASHES
RIVER MUD
SILT
597 PILES
COARSE GRAVEL, COBBLE STONES, BOULDERS
GNEISS = BED ROCK
NORTHRUST FROM DEAD LOAD 1840 TONS. INCL. LIVE LOAD 2000 TONS.
CITY DATUM.
HIGH TIDE.
LOW TIDE.

joints with the adjoining rings. The plates are made exactly alike and interchangeable.

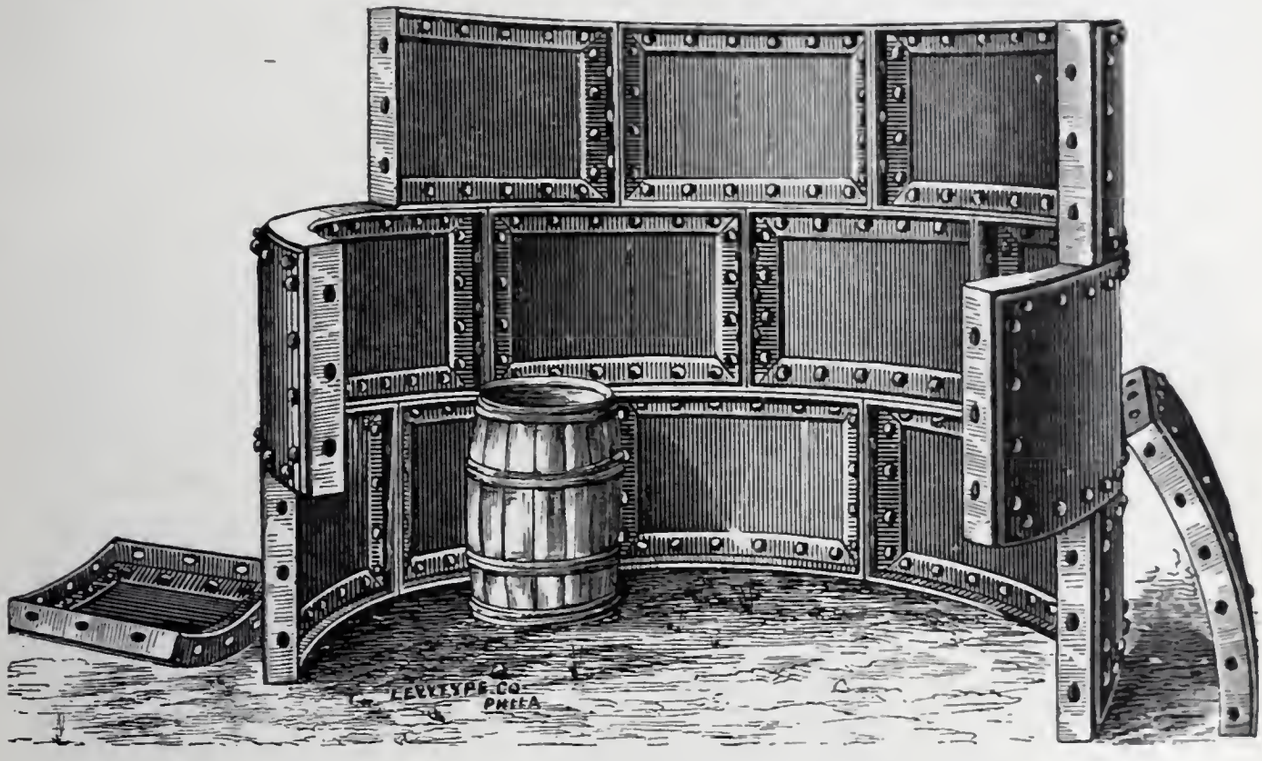


Fig. 1.

The construction of a buttress was commenced by excavating from the surface in the rear of the abutment, a space for a vertical wrought iron shaft 4 ft. in diameter in two pieces; the lower one, intended to remain permanently, was cut and flanged at the lower end to the desired angle of the buttress, and upon this was placed the upper or temporary portion of the shaft, about 8 ft. in length reaching the surface. A few plates of the large cylinder were now connected to the lower end of the shaft and toward the abutment to support a bulkhead of timber, between which and the abutment were rammed earth and mud to support and hold the bulkhead when under air pressure, and the space around the shaft filled to the surface. A double horizontal wrought iron air-lock, 5 ft. in diameter and 12 ft. long with entrances at each end, was then placed on top of the shaft, connections made and the work under compressed air commenced. (Fig. 2.) Plates are now added in the downward direction to those already in position, forming complete rings, with parts of two rings continually in advance at the top, the lower edges approximating a horizontal, holding back the water more readily. The plates were lowered

down the shaft, and the excavated materials hoisted up in canvas bags by means of a block and fall fastened to the top of the air-lock over the shaft. In this order, that is, always keeping two partly constructed rings in advance of those completed, the cylinder advanced towards the rock; as the material was removed for a plate it was put in place, bolted fast, and the joints covered with mud to prevent the air escaping.

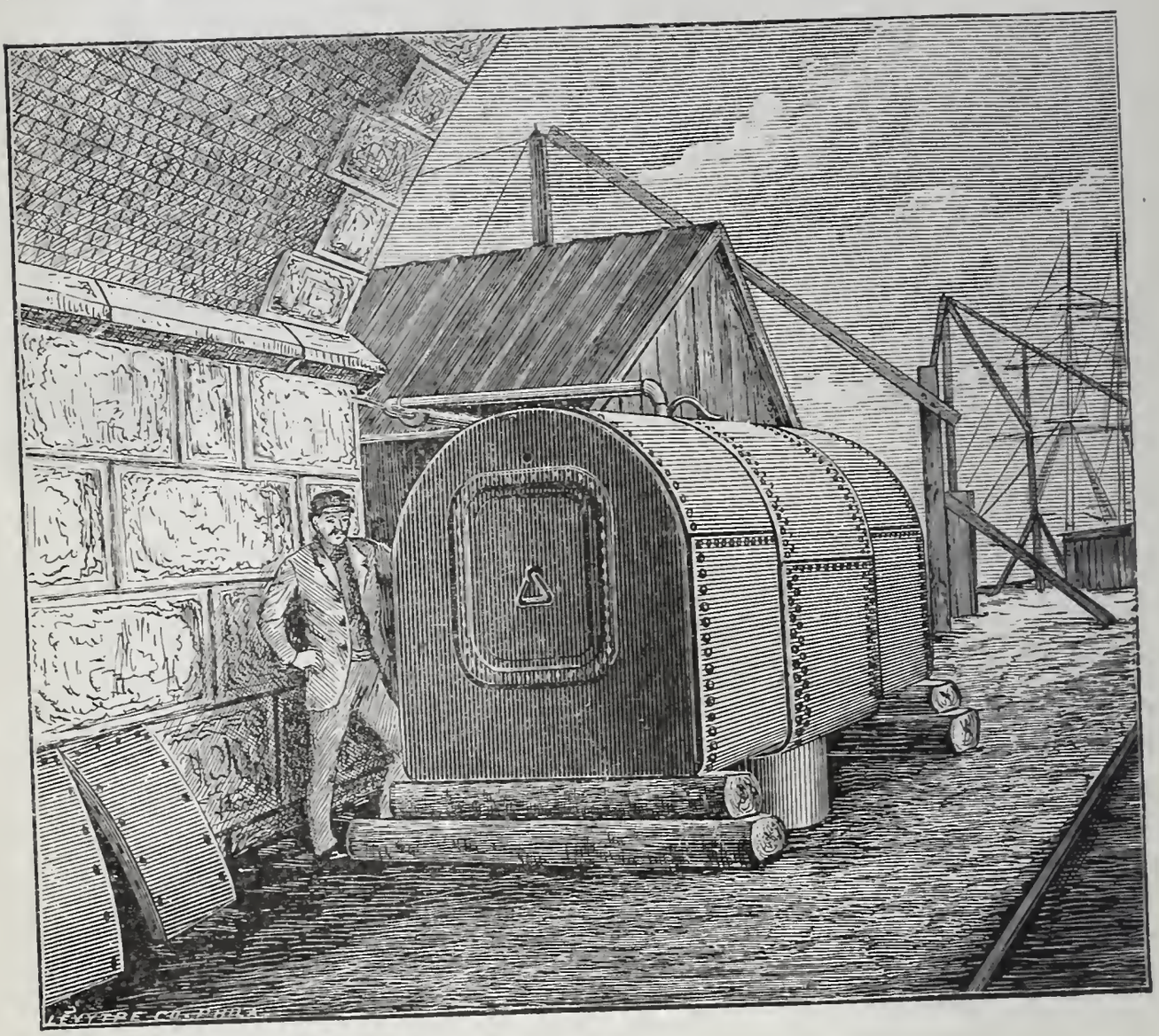


Fig. 2.

When the rock was reached the plates were extended over the surface of it, which was generally horizontal, and the odd spaces covered temporarily with mud.

A shoulder or step, square with the direction of the cylinder, was cut down into the hard rock; occasionally, when very hard seams were encountered, small charges of dynamite were used for blasting, the workmen retreating into the connecting shaft or

air-lock. On account of working a depression into the surface of the rock, without any lower surrounding surface, it was not practical to lower the pressure and allow the water to cover the blast, as is generally done, for the water could not be forced out through the rock.

The cylinder was now ready for filling with concrete, which was composed of one part best German Portland cement, two parts bar sand, and four parts hard broken stone, averaging 2 in. in diameter. The concrete was mixed by hand on a platform outside and passed into the air-lock in bags, and emptied into a box trough extending down the shaft, and leading to an open trough down which it was pushed and turned several times before thrown into place, and then rammed.

This work of concreting was continued without intermission until the lower edge of the connecting shaft was reached, when it was temporarily suspended to allow the lower part of the bulkhead being removed, and the lower shoulder cut into the abutment, square with the cylinder. When this was complete concreting was resumed, and this space and also the permanent portion of the shaft filled with concrete.

The work in compressed air on this buttress is now finished; the air-lock removed, and the temporary portion of the shaft taken out. The completion of the upper shoulder and filling that portion with concrete was done in open excavation.

All work in compressed air was carried on without intermission, except half an hour allowed for lunch, by three gangs of workmen in shifts of eight hours each. Their wages were about the same as generally paid per day for open work, except that they only worked eight hours.

A double air compressor, with 10 in. steam and air cylinders, made by Delamatre & Co., New York, was used, and the Edison system of electric light for lighting the inside of cylinders and outside night work.

The first buttress was one month and a half under construction, but the two last were completed in about one month each, the workmen having by this time more experience and confidence.

Work on the open excavation for the first buttress was commenced on October 9th, 1884, and on November 1st, the cylinder

had advanced into the coarse gravel, and twenty-four hours was occupied in getting one ring in position. On the 10th, rock was reached; 16th, commenced filling with concrete, and on 26th, buttress completed, except upper shoulder against abutment. The fourth and last buttress is now practically completed.

The cost of the work, including inspection, shifting tracks, etc., is about $55.000.

The river mud or silt is slimy and sticky when wet, without grit, and weighs 85 to 90 lbs. per cubic foot. Two briquettes were made by ramming the mud in moulds of one inch square section, and dried in the air. They contracted in drying to seven-eighths of an inch square section; one of them broke at 9 lbs. in two days, and the other at 28 lbs. in seven days.

DISCUSSION.

Prof. L. M. Haupt did not wish to appear to criticise adversely the conclusions of the writer, but he felt disappointed that the paper did not contain some data, which would support the theory which led to the use of the piles in their present position. This misconception of the problem arises apparently from a failure to distinguish which of the equal and opposing forces is the action and which the reaction, or which the power and which the resistance. If the damage to the west abutment were caused by the *thrust of the iron arches*, as alleged, then its effect would be first manifested on the abutment pier and the adjoining brick arch, before reaching the extreme or land side of the second masonry arch. The writer states that this wall has been thrust *back*, whilst his measurements show that the span has been *reduced* in some places nearly half a foot, and that the reduction of span is greatest at the springing line near the head walls, and also near the ground. He admits that the main abutment pier has *not* moved, nor has the one to the west of it, between the two masonry arches, as the eastern span of 60 feet is not affected. The span of the second arch could only be *reduced*, therefore, by its abutment wall moving *forward*.

Prof. Haupt believed that the defects of the bridge resulted from a slight settlement or springing of the piles under the corners of

the foundation of the abutment and approach walls, thus reducing the frictional resistance of the masonry on the grillage, and permitting the excessive pressure of the earth filling, especially when saturated with water, to overcome the inertia of the masonry in these walls, and break the bond, which, in some places, was very weak, causing the large cracks in the approaches and the first arch. He suggested that the remedy should have been applied originally at this point by the introduction of screw or disc piles around the outside of the abutment, by which the unit pressure might have been reduced to any desired extent. The present tubes are being made to abut against a part of the foundation which is admittedly rigid, are placed at some 120 feet from the weak point, and in such a direction as to oppose no resistance to this thrust.

There is nothing in the paper relative to the effect produced by the former remedies of heavy sills and ties, nor to show that they were so inefficient as to render this last device a necessity in any position.

Mr. Howard Murphy thought that these "heavy sills" should never have been built. They are, in reality, built-up horizontal struts or columns, connecting the substructures, and were intended to relieve the main abutment of a portion of the horizontal thrust of the west iron river arch, by conveying it to the approach abutment through the intermediate pier. That they would, if brought to firm end bearings, have increased the stability of the structure, whichever way it has a tendency to move, there is no doubt, if these were all the conditions to be considered. But the Thirtieth Street Extension of the Pennsylvania Railroad passes under one of the arches. The traffic is entirely freight. The heaviest engines and trains may be frequently stopped and started under the bridge, as these tracks are practically a portion of the yard. The struts were laid but a short distance under the surface. If loose, they did no good. If tight, they afforded a very convenient rigid medium for the transmission to the bridge foundations of every shock and hammer blow incident to heavy railroad traffic. The often observed effect of light machinery upon the masonry of buildings, would seem to indicate that a bridge

which could stand this kind of thing without serious rupture, was not such a bad bridge, after all.

As to whether or not the original designs for the foundations of Chestnut Street Bridge had been faithfully carried out by the contractor, Mr. Murphy stated that any assumption of careless *supervision* of the contractors was absolutely inadmissible.

He differed with Professor Haupt as to the easterly or riverward movement of the structure, because there seem to be no cracks or changes which *clearly* show this, and because a failing retaining wall is not likely to bulge, horizontally, *towards* the retained material, particularly when tied at its ends by walls returning at right angles to it, and against which latter walls there is a greater thrust of arch, owing to some excess of weight, of the spandrels and parapets, over the earth-filling in the middle.

Comparison with the accurate transit points, entirely external to the structure, which Prof. Haupt has located, may, however, reveal changes, in one or more directions, now indeterminable.

March 7th, 1885.

Mr. C. G. Darrach submitted his informal discussion of the Repairs to Chestnut Street Bridge, Philadelphia, which he had offered at a previous meeting, but which he had desired to be withheld from the minutes until Mr. Titlow's paper was presented. Mr. Darrach said:—

"Relative to the article in the *Railroad Gazette* on the repairs to the western abutment of the Chestnut Street Bridge, to which our attention has been called by Mr. d'Invilliers, I would state that there are some errors, as well as some omissions, in the description of the failure.

1st. The west abutment of the 53-foot span is at present concave, and not straight as shown.

2d. A very decided crack or break in the retaining wall on the south has developed next to the buttress. This crack runs from 0 under the coping to about 3 inches in width at a level with the spring line of the arch, and is nearly parallel with the face of the end of the abutment, *showing clearly that the masonry has been forced eastwardly.*

The width of this crack corresponds with the shortening of the span.

3d. The crack in the soffit of the arch is wider at the springing line than near the crown, showing that the abutment has spread.

These points of failure show that the end foundations of the ends of the abutment have been pushed to the N. E. and S. E. In addition, the bed of the skewback on the south end is badly crushed. The stones in the abutment under the skewback are badly spalled under the *rear* of the skewback.

In the absence of absolute measurement from a *fixed* point, I am not prepared to say that there has been no movement of the abutment of the iron span westward, as the failure of the west abutment of the 53-foot arch would relieve the pressure exerted by its arch against the 60-foot arch and the abutment of the iron span, allowing the thrust of the iron span to act against its abutment supported only on piles driven in mud.

I am convinced that the *first cause* of the trouble is in the foundations of the western abutment of the 53-foot span; and also that, while the repairs now being made will counteract a tendency of movement in the abutment of the iron span westward, they are only good as a precautionary measure in view of the repairs which have not been finished, and in fact hardly begun."

March 21st, 1885.

Mr. J. Milton Titlow said: "In answer to Prof. Haupt's criticism that '*he felt disappointed that the paper did not contain some data, which would support the theory which led to the use of the piles in their present position*:'

I did not consider it necessary to enter into more details than were given; but will now say that longitudinal measures taken on the roadway from Twenty-fourth to Thirtieth Streets, allowing for inaccuracies in measuring, show in the last ten years a shortening of the distance between the east main abutment and the west approach abutment, being greatest over the brick arches.

Range lines during the last six years have been established to measure positively the movement of the west main abutment, which, by reason of the changes that have taken place on the properties adjoining the bridge, are not now available. That from the apparent condition of the structure, it was positively inadmissible to wait for subsequent changes or movements.

He also says, '*If the damage to the west abutment were caused by the* THRUST OF THE IRON ARCHES, *as alleged, then its effect would be first manifested on the abutment pier and the adjoining brick arch, before reaching the extreme or land side of the second masonry arch.*'

It would be most clearly manifested where the parts are so disposed and of sufficient bulk to offer the most effectual resistance; that is, at the ends of the small abutment, by it being buttressed by the retaining walls, causing chipping, etc., where the joints are fine and close; also the shortening of that part of the span, and a rising of that part of the adjoining arch opposite them.

Between the retaining walls, where less resistance was offered, and the abutment weaker than the arch, it was pushed back; the span at the point of greatest movement not being similarly shortened, and *the shape* of that part of the adjoining arch remaining approximately as originally constructed, the soffit being now lower than at the north and south faces.

The small pier between the approach spans, not being capable of sufficient resistance, the top moved westward somewhat with the 60-ft. span, and consequently this arch was the last to show the change.

He believes '*that the defects of the bridge resulted from a slight settlement or springing of the piles under the corners of the foundation of the abutment and approach walls, thus reducing the frictional resistance of the masonry on the grillage, and permitting the excessive pressure of the earth filling, especially when saturated with water, to overcome the inertia of the masonry in these walls, and break the bond, which, in some places, was very weak, causing the large cracks in the approaches and the first arch.*'

The breaking of the bond or pulling apart of the vertical joints forming the crack, has been caused by a transverse force, the result of the horizontal thrust going in a somewhat diagonal direction to the retaining walls together with an outward movement of the top of the north wall.

From my knowledge of the condition of the filling behind the small abutment, it is not saturated with water above the general surrounding surface, and that its pressure would not be excessive with the thrust of the adjoining arch only against it; and that

this pressure is not the principal cause of the failure of that abutment.

In answer to Mr. Howard Murphy that the horizontal wooden struts under the arches: '*If tight they afforded a very convenient rigid medium for the transmission to the bridge foundations of every shock and hammer blow incident to heavy railroad traffic:*'

They were intended only as a temporary expedient and the only thing that could be quickly applied to answer the purpose. They were designed and built before the railroad that now passes over them, although it was at that time located; and the solid platform was placed under them to prevent their depression and vibration as much as possible.

They may be cut off, after the concrete in the buttresses has thoroughly hardened.

Mr. C. G. Darrach says: '*A very decided crack or break in the retaining wall on the south has developed next to the buttress. This crack runs from 0 under the coping to about 3 in. in width at a level with the spring line of the arch, and is nearly parallel with the face of the end of the abutment,* SHOWING CLEARLY THAT THE MASONRY HAS BEEN FORCED EASTWARDLY:'

This opening above the surface of the ground is not a crack, being only a joint in the masonry out of which have fallen the small stones and mortar, probably by the action of the weather, and has not been mentioned, because it does not indicate an eastward or longitudinal movement, not showing below the surface for two feet, as far as examined.

It does not appear in any form on the north retaining wall.

I believe all the other points are to be found in the paper itself."

Prof. L. M. Haupt called attention to the following communication from Mr. S. Haslett in the *Railroad Gazette* of February 20th, 1885, supporting his view that the defect of the bridge was in the west abutment and due to the weight of the filling and defective foundation. Mr. Haslett presents and explains a diagram, showing a case of failure of a bridge abutment which he had examined some years ago, and continues:

"An examination of the profile of the Chestnut Street Bridge, given in your issue of January 30th, shows a precisely similar condition of things to exist. In the spring

of 1880, when the repairs of that bridge were commenced, I made examination of the western approach to ascertain the cause of its failure. Careful measurements of the spans of the small arches showed that the one nearest the river was of uniform span throughout its length, whereas the landward one varied in such a manner as to show that its west or landward abutment, which was badly cracked, had moved riverward. The abutment pier, supporting the iron arch, and the stone arch next to it did not reveal the slightest evidence of movement, and it is satisfactory to know that Mr. Lindsay's examination corroborates the accuracy of mine. In view of these facts, it is difficult to resist the temptation to believe that the iron struts now being sunk should have their direction reversed, and be pointed toward the embankment in the other bay, instead of toward the iron arches, which seem to have ample support already. S. HASLETT."

He also read the following communication from himself to the Editor of the *Engineering News* of March 11th, 1885, to the same effect:

"UNIVERSITY OF PENNSYLVANIA, PHILA., March 10th, 1885.

"*Editor Engineering News:*—Your notes of the Chestnut Street Bridge in the *Engineering News* of 7th inst. leave room for further information and some explanations. You say 'One party claims that the west river abutment has moved shoreward and the column struts were put in to arrest this movement.'

"This is a natural inference from the fact that these struts were so put in, but by reference to the proceedings of the meeting of the Engineers' Club, published in the same issue, you will see that the engineer department of the city admits that the abutment pier has *not moved.* The drawings submitted also show that the resultant line of pressure, from the iron arch, intersects the grillage at a point situated about one-third of the breadth of base from the river or eastern edge, and not as your article asserts, 'very near the westward end of the timber grillage.' Moreover this resultant pressure is opposed by that of the brick masonry arches on the west, and it is only the difference of the horizontal components of these forces that tends to produce any sliding of this abutment. But the masonry is also 'toed' into the grillage to prevent this 'tendency,' and it may safely be asserted that there has been no movement here. Your remarks as to the earth filling being the cause of the bulging and the wedging apart of the piles, are directly to the point. The cause of failure in this case is very similar to that of the west approach to the South Street Bridge, viz., the vertical sinking of the piles and consequent thrusting *forward* of the face of the unsupported masonry.

"This masonry face has not *bulged* horizontally *toward* the retained material,' as is stated in the record of proceedings. This would *increase* the span, but it has been pushed out into the non-resisting air space of the span, thus diminishing its original dimensions as shown in all the reports on the bridge, by nearly half a foot at the corners, thus giving it the appearance of having *bulged.*

"The Review also says that 'the riverward movement of the structure,' is not evident, 'because there seem to be no *cracks* or changes which clearly show this,' etc. Possibly all engineers may not deduce the same conclusions from *cracks.* It has not, I believe, been clearly stated in any of the printed reports that there *is an old crack,* wide open, EIGHT INCHES at the surface of the ground, and *four inches* at 7 ft. above,

extending vertically up the rubble masonry of the south retaining wall at its junction with the eastern face of the heavy buttress, which stands about 25 ft. to the rear of this abutment. Any one may readily insert his arm therein, full length. There are also numerous minor cracks on the soffit of the western arch, and its supporting wall, both vertical and oblique, which clearly show the direction of the movement and settlement.

"Instead of these outward and visible signs being most abundant and most marked at or near the *abutment pier* and gradually diminishing towards the approach, as would be the case had the movement started at this pier, exactly the reverse obtains.

"The only thing my transit points will show is that the abutment pier is not moving. A result which may be safely anticipated, and I believe it is admitted by those who have inspected the bridge carefully that there has been no perceptible movement for some years. Then why these repairs? Respectfully yours,

"LEWIS M. HAUPT, *Prof. of Civ. Eng.*"

MR. HOWARD MURPHY, in reply to Mr. Titlow as to the wooden struts, still maintained that even *temporary relief* is not likely to be afforded to failing masonry by placing its foundations directly under the influence of the heavy yard traffic of the Pennsylvania Railroad, at the foot of a heavy grade.

"As to the cracks referred to in Prof. Haupt's article, in *Engineering News*, whereof he says,—'Possibly all engineers may not deduce the same conclusion from cracks,' Mr. Murphy respectfully submits that arguments must be based upon facts. Therefore, when Mr. Titlow asserts, as he has asserted, that the principal 'crack' in question is not a crack, but an opening which was left there when the masonry was built; that it was afterwards filled with small stones and mortar; that the latter, in that portion of the 'crack' above ground, have since dropped out; and that he had the masonry uncovered for some distance below the surface of the ground and there found the above filling, in place, in the 'crack'—these statements form part of the evidence.

If the above assertions, and others of like character, which have been offered as facts by the author, are facts, I still maintain that the existence (or non-existence) of this 'crack' does not show an easterly or riverward movement of the masonry, and that such movement is not clearly and conclusively shown by any other given data.

I closed the remarks to which Prof. Haupt refers by saying,—"Comparison with the accurate transit points, entirely external to the structure, which Prof. Haupt has located, may, however, reveal changes in one or more directions, now indeterminable."

Mr. Rudolph Hering said:—

"I am somewhat at a disadvantage in discussing Mr. Titlow's paper, as I was unfortunately absent when it was read. Nor have I as yet read the other discussions on the matter. As I had occasion, some years ago, to make a number of measurements at the bridge, and formed then my own conclusions regarding its movements, I will state my views without reference to Mr. Titlow's paper. These views I expressed informally after a meeting of this Club in 1880.

To rightly understand the present condition of the bridge, it is necessary to discuss certain of its features independently of each other, as, I think, the trouble results from several independent causes.

First.—The steps that have recently been taken to secure the stability of the bridge, are based on the supposition that the western abutment pier is moving westward. I do not think that this supposition is sufficiently substantiated by the facts, although certain appearances would lead one to infer that it was. The spaces for the expansion of the iron cornice measured, on a very hot summer day a few years ago, about $\frac{3}{4}$ inch on the east, and a little over 1 inch on the west river arch, showing therefore that if there had been actual contact, at such a temperature, when the bridge was built, the extreme movement since then could not have been over the sum of these figures, or 2 inches. It is to be supposed, however, that there was some extra space allowed for. Moreover a westward movement of 2 inches in the abutment, would have required the pier to move about $\frac{3}{4}$ inch. A westward movement of the abutment pier would have affected the first brick arch by raising it, and, in this way, exhausted its force. It could not have extended across the arch, and moved the small pier beyond, much less the second arch, which is the one most distorted. It must be remembered that the line of thrust from the river span, down into the abutment pier, strikes inside of the platform, and I believe also inside the footing of the piles. From these facts, I think, it can readily be concluded that there has probably been no motion at all of the western abutment, and positively not over 2 inches, an amount quite insufficient to explain the buckling of the brick arches.

Second.—Marks were made every 50 feet on the curb-stones, beginning at the west house line of Twenty-third street. A remeasurement of these marks showed a lengthening of the distances on the west slope of the bridge, indicating unmistakably a westward movement of the curbs. This led, at first, to the supposition that the west abutment was moving, but from the fact that a slight *shortening* of the distances between the marks occurred on the *east* slope of the bridge, I think the movement of the curbs is to be attributed to a down-hill crawling, similar to that of a track on a down grade.

Third.—That the steep grade of the western approach of the bridge, being over 4 feet to 100, has an effect also upon the form of the brick arches, I think there can be no doubt. A bridge in Switzerland, consisting of a series of arches, with a surface on a grade of over 5 to 100, was described in a European publication, some years ago, as having required extensive repairs due to the deformation of the arches caused by the unequal loading of the haunches on the steep grade. This deformation consisted in the flattening of the arches on the up-hill side and a corresponding pushing up on their down-hill side. The two brick arches on the western approach of Chestnut Street Bridge show the same deformation, the up-hill side of the arch being flattened. In fact, the same thing is noticeable in the arches on the *east* side of the bridge; but it is not as great, owing, no doubt, mainly to the fact that the grade there is less.

Fourth.—The westernmost brick arch is buckled considerably more than any of the others. This is caused by another feature of the bridge, and, I think, the most serious one. The west abutment and a portion of the approach are built on the site of an old canal or slip. The ground consisted mostly of fine mud. The abutment and retaining walls were built upon piles capped with timber platforms. Soon after the filling was put in behind the walls, a considerable bulging out occurred, caused by the weight of the earth filled in, pressing down and out into the soft mud into which the piles were driven. This was so great on the south side, that it was necessary to drive additional piles and build the wide buttress now existing about 50 feet back of the abutment. At the same time, and no doubt owing to the same

cause, the platform upon which the west abutment rests, not being connected with the platforms under the retaining walls, was pushed out towards the river. There seems to have been little, if any, movement in this abutment since that time. About six years ago, it was feared that the retaining walls over the old slip were bulging, judging from the settlement of the roadway, and about half a dozen $2\frac{1}{2}$ inch or 3 inch iron tie-rods were put through the walls near the top of the ground, and fastened with heavy timbers, thus effectually guarding against any further bulging at that place. Nothing has been done to the west abutment since its first movement. The present position of the buttresses on the north and south sides, shows that the foot of said abutment, at the corners, has moved out about 5 inches. On the south side, the opening caused by this movement shows itself as one crack, from nothing near the top to about 6 inches near the bottom. On the north side, the opening is divided among a number of joints in the rough rubble masonry. The face of the west abutment is concave, the concavity measuring about 5 inches at the springing line, and probably nothing at the platform.

The reason why the face has this peculiar surface, can be explained as follows:—The buttresses on each side, being built of cut stone masonry, well bonded with the abutment, give the ends of the latter such a rigidity that, when the foot was pushed out, it carried the skew-back of the arch, and therefore the arch itself, with it; both buttresses remaining perfectly straight, although out of plumb. The centre of the abutment did not move out correspondingly, because of the relatively greater resistance of the arch, on account of the wall in the centre not having the strengthening benefit of the cut stone face work and buttresses, and also being of much less thickness at that place, a fact not indicated on the plans. The centre of the abutment was even further weakened by a crack from the arch down to below the surface of the ground.

This moving out of the west abutment, as indicated above, necessarily pushed the ring-stones and the adjoining brick arch *eastward*, and this movement, in addition to the other cause already mentioned, explains the much greater raising and cracking of that particular arch.

To recapitulate—It seems to me:—

First.—That the west abutment which has recently been braced by concrete cylinders, has moved very slightly, if at all, being the only part of the bridge on the west side of the river, which is plumb, which has not settled and shows no cracked stones.

Second.—That the horizontal timber struts put in under the brick arches, if they show, at present, any compression at all, are compressed rather by an *eastward* movement of the west abutment, than by a *westward* movement of the abutment pier.

Third.—That the deformation of the brick arches is partly accounted for by an unequal loading of the haunches, due to the heavy grade of the bridge.

Fourth.—That the greater deformation of the westernmost arch is caused by the eastward movement of the west abutment, which appears to be the main cause of trouble, but for which avowedly no remedy has as yet been applied."

April 4th, 1885.

Mr. C. G. Darrach said:—"In Mr. Titlow's criticism of my discussion of the failure and repairs to the Chestnut Street Bridge of February 7th, he says with regard to the crack in the south retaining wall of the western approach (33 ft. 9 in. west of the face of the abutment): 'The opening above the surface of the ground is not a crack, being only a joint of masonry out of which have fallen the small stones and mortar * * * * not showing below the surface of the ground for two feet as far as examined.'

I would respectfully submit, that a straight joint does exist in the masonry at this place, but it is not probable that it was originally built five inches wide near the surface of the ground and with a close joint at the top of the wall under the coping. An engineer would not have allowed, nor would a mason have built, such a joint. An examination of this opening shows the cast of the stones (which are now in the wall) in the mortar on the opposite sides of the crack.

Since hearing Mr. Titlow's paper I have made the following measurements and observations:

MEASUREMENTS OF WESTERN APPROACH OF CHESTNUT STREET BRIDGE.

MEASURED ON	—53 ft. Brick arch.	—Pier.	—60 ft. Brick arch.	—West abutment.	Pier of iron span.
		On north face of approach.			
A—West abutment	×52 ft. 6⅝ ins. . .	× 8 ft	×59 ft. 11½ ins. .	× "	"
B— "	×52 ft. 5¾ ins. . .	× 8 ft.	×59 ft. 10¾ ins. .	× "	"
		Through middle of approach.			
A— "	×53 ft. 0⅛ ins. . .	× 8 ft.	×59 ft. 11¾ ins. .	× "	"
B— "	×52 ft. 10⅜ ins. .	× 8 ft.	×59 ft. 11 ins. . .	× "	"
		On south face of approach.			
A— "	×52 ft. 7⅞ ins. . .	× 8 ft.	×60 ft. 0 ins. . .	× "	"
B— "	×52 ft. 6¾ ins. . .	× 8 ft.	×59 ft. 11¼ ins. .	× "	"

NOTE.—Measurements on the lines A are taken on the level of the bed of the skewbacks. Measurements on the lines B are taken on the level of the top of the water table, which is 6 ft. 8 in. below the bed of the skewback.

In this height, viz., 6 ft. 8 ins., the *west abutment pier*, of the iron river span, leans one-eighth of an inch to the west, but seems to be plumb above that point. It is cracked in and above the beveled courses of the buttresses at the northwest and southwest corners.

The *pier* between the two brick arches is badly cracked through in several places and leans $\frac{7}{8}$ of an inch to the WEST in the 6 ft. 8 in. between the water table and the skewback, and $3\frac{5}{8}$ in. in its total height of about 29 ft. at the coping.

The western abutment of the 53 ft. brick arch leans out at the bottom (in the 6 ft. 8 in.) to the east as follows: at the north end $1\frac{3}{4}$ in.; in the middle, $2\frac{3}{8}$ in., and at the south end, 2 in. This abutment is curved out at the ends to the east and a line stretched between its extremities shows the springing line to be 2 in. lower at the ends than at the centre.

The voussoirs at each end over the skewbacks are cracked in the soffit of the arch. The face of the abutment is cracked in several places, and its length measured at the springing line is 42 ft. $9\frac{1}{8}$ in., or $2\frac{1}{8}$ in. longer than the pier between the two brick arches. The largest crack is 4 ft. 5 in. north of the middle of the abutment, and is $1\frac{1}{4}$ in. wide at the springing line, and one inch wide at the water table.

The isometrical sketch made from these measurements seems to indicate: that *the abutment pier* of the iron river span has moved to the WEST $1\frac{1}{4}$ in. at its north end, 1 in. at the middle, and three-fourths of an inch at its south end.

The *pier* between the two brick arches seems to have retained its original position at the level of the water table, but to have been pushed to the west about seven-eighths of an inch at the level of the skewbacks, and $3\frac{5}{8}$ in. at the coping, on the level of the roadway.

The western abutment has moved both horizontally and vertically, its ends sinking, the length increasing and the line of top of water table moving in a curved line to the *east* as follows: at the north end $6\frac{1}{4}$ in., at the middle $1\frac{5}{8}$ in., at the south end $5\frac{1}{4}$ in.

That the line of the face of skewback has moved *east* at the ends of the abutment and to the WEST in the middle, as follows: at the north end $4\frac{1}{2}$ in. *east;* at the middle $0\frac{3}{4}$ in. WEST, and at the south end $3\frac{1}{4}$ in. east. The distance between the stone in the south face of the retaining wall at the crack (33 ft. 9 in. west) at this level, and its imprint in the mortar opposite measures 2 in.

The 53 ft. brick arch is distorted and its crown raised; the 60 ft. brick arch is also distorted and its crown raised, but not so much as the 53 ft. arch.

I think these measurements will confirm my remarks made February 7th, and published in the Proceedings of March 7th.

As I understand Mr. Titlow's paper, his contention is that the *centre* of the western abutment has been pushed back at the springing line *five* inches to the *west.*

From the observations noted such a movement would have required the small pier to have moved 5 in. and the abutment pier to have moved at least 6 in. to the west, for the 60 ft. brick span has been shortened 1 in. and the 53 ft. brick span about 5 in."

Mr. Rudolph Hering said, that the views contained in Mr. Titlow's paper regarding the cause of failure of the bridge, which were further amplified in his subsequent discussion, were untenable on both mathematical and physical grounds, and supported his opinion by blackboard illustration and a model, kindly prepared by Mr. C. E. Taylor, C. E. He explained at length that the existing cracks, bulges, distortions, chipping of coping, change in position of curbs and other signs of motion in the bridge, while they could not be accounted for by a movement of the pier recently

strengthened, they could, however, readily be accounted for on the grounds mentioned by the speaker at the previous meeting, and mainly by the earth-pressure in the approach.

He thus concurred in the views advanced by Prof. Haupt, Mr. Darrach, Mr. Lindsay, Mr. Haslett and others.

Finally Mr. Hering said that while he thought this explanation of the failing of the bridge, in opposition to the one advanced by Mr. Titlow, incontrovertible, he considered that a difference of opinion might be held as to whether or not the recent expensive work was of use simply *as a first step* towards remedying the real defects, by giving the abutment pier additional security while the brick arches and west abutment are being repaired. He himself, however, believed that the horizontal struts placed several years ago under the arches, and extending from the west abutment to the abutment pier, would have sufficed during such repairs to resist any dangerous horizontal thrust from the latter.

Prof. L. M. Haupt submitted some photographs of the two western masonry arches and the buttress on the south side of the retaining wall, to show that these portions of the approach do not conform with the neat lines of the segmental arches, as originally designed. The points of sight for the camera were taken in the vertical planes through the axes of the arches to eliminate any distortion due the lens. The views showed a measurable depression of the spandrels on the up grade, and a corresponding elevation on the down grade side. It was his intention to have measured this distortion upon a screen, but an opportunity had not been offered.

Various questions also were asked, and remarks made, by many of the members present.

April 18th, 1885.

Dr. H. M. Chance opened the discussion, giving the result of his examinations of the displacement of the railing.

A number of members participated, but it appeared that no change of previously expressed opinions had taken place.

V.

THE CONSTRUCTION OF STREET RAILWAYS IN THE UNITED STATES.

By William Wharton, Jr., Member of the Club.

Read March 7th, 1885.

To a considerable extent I have in this paper taken from the report made by me as Chairman of the Committee on Completed Construction of New Road, read before the American Street Railway Association, at their meeting in New York, on October 16th, 1884, which was adopted and its conclusions approved by the Association at that time.

In the construction of street railways there are various matters which influence the details in such a way as to prevent the adoption of all the improvements that would be desirable for the use of the railway cars alone, and in this respect the builders of street railways are at a great disadvantage compared with those who lay down steam railroads, for it is evident that while we must endeavor to get the best roadway for the cars, due regard must be paid to the requirements of general travel along the streets, and to the local laws—often very unreasonable—which govern the form of rail and other details. So that we are not at liberty to use the best means to accomplish the end desired; in fact the matter is often so hampered with municipal regulations, that it is impossible to accomplish more than an imperfect and unsatisfactory solution of the problem.

The best form of rail for the purposes of the railway company alone, especially where the streets or avenues are wide enough to provide the general travel of the street with a good and sufficient roadway outside of the space occupied by the railroad tracks, is, undoubtedly, the "centre-bearing," as the weight of the car wheel in this case bears directly upon the centre of the rail and is transmitted evenly to the centre of the stringer, so that the track is in the best position to resist the outward pressure which is constantly tending to widen its gauge, and otherwise injure its condition. The spikes with this form are placed alternately on either side of the head, so that the rail, besides having a better bearing

on the timber, as above stated, is held down equally on both sides. The car wheels run more smoothly and with less friction than upon any other form, as there can be no possible contact with any paving stones, and the open space provided on the outside has a tendency to keep the head of the rail free from dirt and grit. This is especially the case during cold weather, when one of the most serious difficulties in operating street railways arises from frozen mud, ice or snow, getting upon the rails, even when the greatest care is taken to keep the track clear. The centre-bearing is the standard street rail now in use in New York City, and it is used to a considerable extent in Brooklyn, and a few other places.

In the next form, known as the "slope-back," the bearing is approximately in the centre, the head being about three inches wide and beveled or sloped off on the outer edge, so that to a certain extent, it gives the advantages above enumerated for the centre-bearing rail, but only to a limited degree.

The "side-bearing" pattern, with its many variations, is that which is most generally in use in the United States, not because it is the best, but because it is the best that the railway companies are permitted to put down, as wagon-wheels can readily get on the track, and it gives a good wide tramway for general travel. This very fact, however, is a great detriment, as the general traffic is invited by its smoothness and other advantages to run upon it. Heavy teams going at a slow rate are constantly in the way of the faster moving cars, and the rails are not only worn out by this travel, but the speed of the cars and the general business of the road interfered with. A very serious objection to all side-bearing forms is that the weight of the cars being entirely on the outer side, that part of the rail wears into the stringer sooner than the other, causing the rail to roll out of level, thus widening the gauge of the track. All forms in which the head of the rail is narrower than the tread of the car-wheel should be avoided, as the wearing surface is too little, and in the side-bearing patterns this is especially the case, for, unless the head is as wide as the tread, the projecting edge of the wheel will be constantly striking against the paving stones outside of the rail when the track is new, or the pavement is re-laid. This will only cease when the paving stones shall have been gradually worn

away by the action of the wheels, which is a very objectionable and costly process, or when they shall have been knocked down or otherwise settled below the head of the rail.

In England and in some other countries the standard rail for street railways or tramways is a flat rail having a narrow groove in it, just wide enough to admit the passage of the car-wheel flanges, but not wide enough to allow the wheels of any ordinary vehicle to get in it. Such a rail, although in some respects the best for traffic other than the railway cars, could not well be used in this country, particularly in the northern parts, owing to the liability of the narrow grooves being clogged up with dirt or mud. This would especially be the case in winter, as it would be almost impossible then to keep the cars upon the track, as the grooves would be constantly getting filled with frozen mud or ice. Although rails of this form allow wagon wheels to cross them freely in all directions, this very thing is of itself a drawback to the use of the railway track by ordinary vehicles, as there is nothing to keep them in line upon the rails. Street railways or tramways give a first-class opportunity for the hauling of heavy loads of freight through cities in ordinary wagons, and if the flat English grooved rails were used, they would, for the reason just stated, not be as good for that purpose as rails of the usual forms used in the United States.

Where the service is heavy, a rail weighing sixty pounds to the yard will be found the most satisfactory, and in the end the most economical; but upon roads with lighter travel this is not necessary, though it should always be borne in mind that it is impossible to get satisfactory results when materials of poor quality or insufficient size or weight are used. It is not the first cost that should be regarded altogether, for if the railway is well built with good and sufficient materials, the annual wear and tear will be proportionately reduced, so that the profit and loss account from year to year will not be charged with constant repairs, rendered needful by poor or scanty construction at the outset.

The spike-holes should be about twelve inches apart, so that when the rails are first laid, it will be enough to spike every alternate hole, thus leaving new holes with their original coun-

tersink to be used when the others shall have become worn too large and be unfit to retain the spikes. The rails should be carefully inspected, and any that are not cut square at the ends, or not straight and level, should be rejected and returned to the mill.

As the gauge of street railways is almost always established by the local authorities to conform with the legal gauge of the ordinary vehicles of such city, there is, in consequence, no universal or standard gauge for them. From four feet eight inches to five feet two inches gauge will give the most satisfactory results, as a general rule, especially for double teams, as there is not sufficient room for the horses to travel properly if the gauge is less than four feet eight inches, without their treading upon the smooth surface of the rail, which would probably cause them to slip and injure themselves.

Where double tracks are laid, there should be ample space for the cars to pass each other on both the straight tracks and the curves. Five feet between gauge-lines, unless the cars are exceptionally large and wide, will be a sufficient distance; and on straight tracks it will also allow a man to stand between the cars while passing each other, which may prevent many accidents.

All joints of the rails should have rolled iron joint-plates, not less than eighteen inches long, placed under them. These should have vertical flanges to fit against the sides of the rails, so as to keep them in line with each other, and to increase the vertical strength of the joint-plate itself. If the track is laid in cold weather, the joints of the rails should be kept apart three-eighths of an inch to allow for expansion of the rails in summer; and this space should be less as the temperature rises, although the ends of the rails should never be laid less than one-eighth of an inch apart even in mid-day of the very hottest weather.

The rail-spikes should be five and a half or six inches long, of one-half inch square iron, with countersink heads, to fit into and not project above the countersink in the rail itself. They should be of good tough iron, so that when driven, the heads will not fly off under the strokes of the hammer.

As street railways are now usually constructed, the rails are placed upon longitudinal wooden stringers, resting upon trans-

verse wooden cross-ties. Where it can be obtained at a reasonable cost, yellow pine, free from sap-growth, and cut from trees that have not been tapped, should be used. As a general rule, the best yellow pine railroad lumber is brought from Georgia or Florida, and in all cities near the seaboard, at least, the rate of freight is low enough to justify its use for stringers and cross-ties. Of course, this may not be so in cities or towns far inland, and in such cases, other lumber must be used which can be more conveniently and reasonably obtained. The ties should be of equal size, in order to give a uniform bearing and support to the track; for if they are of unequal surface, the track will be better held up by the large ties than the smaller ones, thus causing it to be uneven and irregular. For the same reason, they should be placed at a uniform distance apart, five feet from centre to centre, being, probably, the most desirable. Uniformity of dimensions can be more certainly had if the ties are sawed than if hewed, and in addition to this the stringers will then always have a good flat bearing upon them. The joints of the stringers should never be under the joints of the rails. The stringer should be not less than seven inches deep, and of the same width as the rail which is to lie upon it, unless it should be one of the narrow forms of rail, in which case the timber should project on both sides not more, however, than one-half inch. It should then be beveled off on the upper edges to the width of the rail before putting down the pavement. The stringers should be, at least, twenty-five feet long, in lengths divisible by five feet, so that there will be no waste in cutting off useless ends to allow the joints of the stringers to come exactly upon the cross-ties. Of course, where there is exceptionally heavy service, it may be of advantage to place the ties four feet from centre to centre, and the size of the ties may then be increased to advantage, say five inches high by seven inches wide, although generally four inches by six inches is large enough. The ties should project outside of the stringers on both sides at least nine inches, and the stringers on the outside should be fastened to the ties by cast iron knees, not less than six inches high and six inches long, and on the inside by similar knees three inches high and three inches long. The large knees on the outside tend to keep the stringer in a

perpendicular position and so to preserve the gauge of the track. At all joints of stringers, joint knees should be used on both the inside and outside of the stringers, and they should be broad enough to bear against and be spiked to the contiguous ends of the same, thus keeping them in line. The spikes used for these cast iron knees should be three and a half or four inches long, and three-eighths of an inch square, with button-heads. The knees should be of good strong iron, so as not to break easily, in case the workman should miss the spike and accidently hit the knee itself, and all the spike-holes should be carefully drifted out, so that in driving the knee-spikes, they will not wedge in the holes and split the knees.

It is very important to have the ties and stringers well and solidly tamped-up, and a straight line and even surface carefully obtained. This is a matter which is often slighted, but which should be attended to with great care.

A very troublesome and expensive item of repairs is often caused by the wheels of heavy wagons making ruts alongside of the rails, thus causing the track to get out of gauge, and otherwise wrenching and injuring it. This can be, in a great measure, prevented by putting a row of substantial square-shaped paving blocks on each side of each rail, which, after being thoroughly rammed, should be left about one-half inch above the rail, otherwise they will settle down so as to be below the rail, when their efficiency will be greatly lessened. Although it is very seldom done, it is a great advantage to bed the block stones next to the rails upon a layer of concrete, which will greatly help to keep them from being pressed down out of position.

All the undisturbed bed between the cross-ties should be loosened up with the pickaxe, so that all of the pavement shall have the same bearing, and it will settle alike all over.

The best pavement for the horse-path is, probably, had by using cobble stones about six inches long, about four inches wide, and two or three inches thick. These dimensions give stones of moderate size, and of flat, oval form, so that when closely set on end, they furnish a very good foothold for the horses, and the pavement can be kept in repair at a very reasonable cost. The

horse-path should be paved as nearly as possible level, and all crowning or elevation in the middle of the track should be avoided, so as to allow the horses' feet to travel evenly and squarely. The stones should be laid upon a bed of good sharp gravel or coarse sand not less than six inches deep; they should be thoroughly rammed three times, and left with a covering of the same material about one-half inch deep, from which all stones over an inch long should be raked off. As by far the greater number of horses worn out in street railway service become so from injuries or weakness of their feet or legs, this matter of suitable pavement is a very important one to street railway companies, and it has been proved beyond doubt that horses traveling upon cobble stone pavement carefully and properly laid, last longer than when any other form of pavement is used.

At proper and frequent intervals suitable connections should be made with the sewers, or with surface drains where sewers are not in use. If this matter is not properly attended to, great inconvenience and expense will be caused, especially in cities where the melting of snow during the winter causes a great accumulation of water upon the track, which, if not promptly removed, may, by a sudden change of weather, freeze up solid on the track. In any event, no track can be properly kept in order unless the surplus water is promptly and adequately drained off. The general elevation of the whole track should be a little higher than the rest of the street, to aid in draining the water away from the track.

The radius of the curves will be governed by the width of the streets and other conditions, but it is always desirable to avoid curves of small radius. A curve of fifty or sixty feet radius is probably the most desirable when it can be laid down; but in many cities the width of the streets will not permit curves of more than thirty or thirty-five feet radius, which, however, if properly laid, will give all reasonable satisfaction. The curved rails should be of the grooved form, on both the inside and outside lines of the curve, although in curves of large radius it is not necessary to have the outer line laid with grooved rail, in such cases bending the rail used upon the rest of the track to the proper shape. The groove should be about one and a half inches

wide, and the inner side, or guard, of the grooved rail, should not be more than three-eighths of an inch above the tread. Great care should be taken in laying the curves to have them of regular curvature, uniform gauge, and with no abrupt changes of surface. Ordinarily, a curve laid with the inner and outer rails on the same level will give the best results in service, but there are instances, when, from the grade of the streets, it will be found necessary to elevate one rail higher than the other. The outer rail may then be elevated a few inches above the inner without any disadvantage; but the inner rail should never be higher than the outer, if it can possibly be avoided, although a slight difference in this respect, where absolutely unavoidable, can be allowed, if the curve is very carefully and accurately put down. The curves should always be so constructed that all four wheels of the car will bear equally upon the rails; as otherwise, if any one of the wheels should have its portion of the load removed from it by reason of a depression in the track, it will have a tendency to run off the curve at that point. The curved rails should be, when practicable, in lengths of thirty feet, so as to have as few joints as possible; and a straight guard rail, not less than seven feet long, should be attached to each end of the inner line of the curve.

On single-track railways where it is necessary to have turnouts, or passing places, they should be so constructed as to allow the cars to run easily into and out of the turnout. This can be accomplished by making the curves leading into and out of the turnouts of large radius, say three hundred or three hundred and fifty feet. As, however, in cities, the length required for this form of turnout is often inadmissible, it will then be necessary to use curves of shorter radius, and a turnout with grooved rails of seventy-five feet radius, will, probably, be found the most desirable under such circumstances. Where the curved rails of the turnout are of three hundred or three hundred and fifty feet radius, it will not be necessary to use any grooved rails, as the ordinary rails, when carefully curved, will be sufficient to guide the car-wheels.

The castings for all switches, frogs and crossings should be made from hard, tough iron, and of substantial size and weight.

At each end of the casting, there should be a recess or pocket of the right size and shape to support and retain in position the end of the adjoining rail; or, when two castings themselves abut, the end on to which the cars run should rest in a pocket formed in the end of the other casting. Particular care should be taken to have all the castings evenly and solidly bedded upon the timber supporting them, for otherwise they are liable to be broken by the shocks and strains of heavy loads crossing over them. At places where frogs or crossings are required, and one of the tracks is used very much less than the other, it will often be found desirable to have the castings so made as to allow a continuous rail to run through a recess in the casting, thus giving an unbroken rail to that one of the tracks which has much the greater travel, while the occasional cars running on the other track have their wheels so raised up that their flanges pass readily over the top of the continuous rail. "Toe-pieces," or slight projections, should be made on all castings, when, by the size or smoothness of the surface exposed, horses are otherwise liable to slip upon them, smooth spaces being left only where the car-wheels run.

As the standard depth of the flanges of wheels on street cars is only nine-sixteenths of an inch, while the standard depth of flanges of car wheels on steam railroads is one and a quarter inches, it is evident that great care must be taken to have all curves, crossings and switches on street railways made with accuracy and put down very carefully.

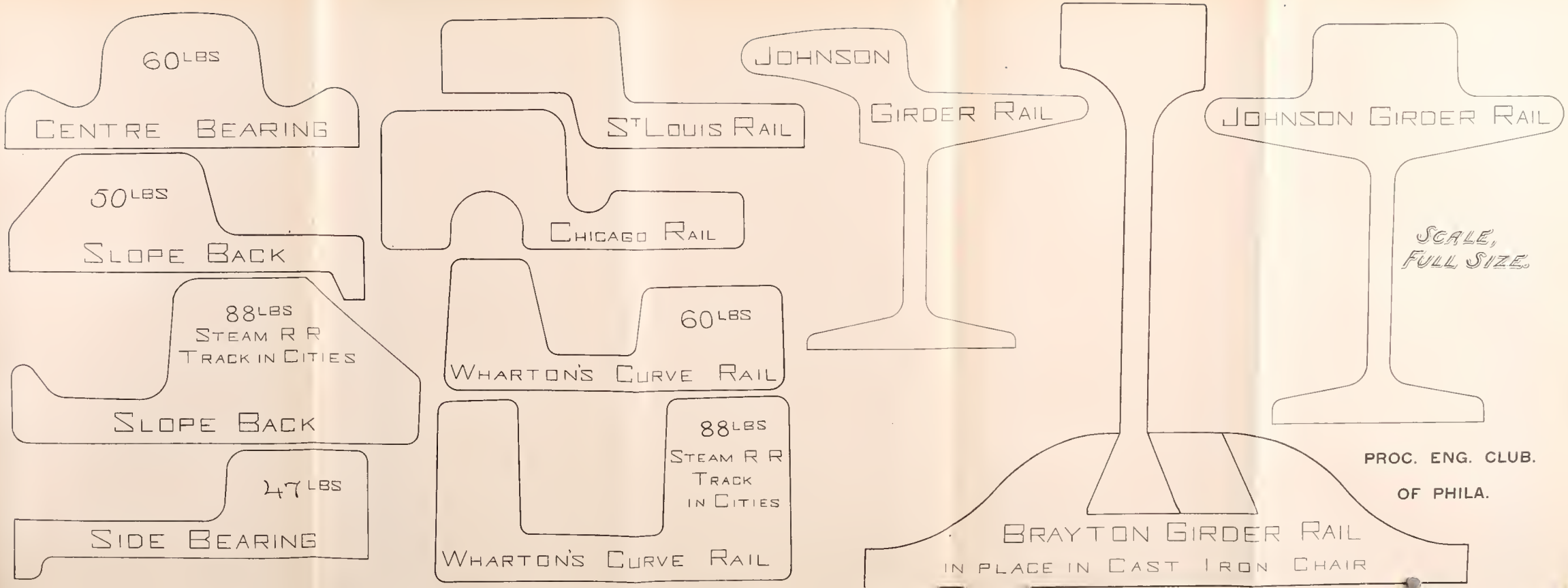
The use of turntables should be avoided wherever it is possible, but as they will often be found necessary, it is important that those only should be used which will turn easily, present little or no obstruction in the street, and require but a reasonable amount of repairs when in use. They should be set on brick or stone foundations laid below the frost-line, and they should be thoroughly provided with drainage.

Within a recent period, and especially within the last five years, a very radical change has taken place in the manufacture of rails, whether for steam or horse railroads, the material now used in the construction or repair of railways being almost universally steel instead of iron; in fact, it would be very difficult

to get iron rails, as the mills that formerly made them have gone out of the business, or have changed their plant to make steel rails instead. The improvements in the manufacture of steel have been so great that there is now no inducement to use the inferior article, as the superior can be had at the same or a less price. The service of steel rails on an average street railway is, probably, at least three times that of iron rails of equal size and weight, the wear of the steel rails being also more even and regular. One great cause of the rapid deterioration of iron rails furnished for street railway use, arose from the fact that they would laminate and often split off in pieces of considerable size, so that the surfaces were not only worn away, but actually broken away and splintered off. Steel rails, on the contrary, being of homogeneous and tough material, are not subject to this objection, every particle that is worn off under service coming away by itself, but not dragging with it any other portion of the mass.

Up to this time I have not referred to the various forms of girder rails, largely used in European cities, and within the last few years introduced to a considerable extent in the United States, by which wooden stringers and ties are altogether avoided. One great advantage that they give is that a perfectly secure and level joint can be had at the ends of the rails, as fish-plate joints can be used similar in general character to those in use on steam railroads. The deterioration of the railway by reason of the decay and wearing-away of the stringers and ties is avoided, as no timber is used with them. Thus not only is a much smoother track obtained by their use, but the durability and life of the railway is very much increased. It is almost certain that the standard street railway of the near future will be constructed with steel girder rails, set on iron or steel supports, or cross-ties, and held to gauge by iron tie-rods.

In the Johnson system of girder railway construction, the rails, when laid in the street, present the same form and appearance as those of the usual kinds. Various forms of side-bearing and centre-bearing rails are made by this system, but they have a stem and base attached to and forming a part of the rail, very similar in general appearance to the stem and base of the ordinary T rails. This stem and the base are made of any desired


60 LBS
CENTRE BEARING
50 LBS
SLOPE BACK
88 LBS
STEAM R R
TRACK IN CITIES
SLOPE BACK
47 LBS
SIDE BEARING
ST LOUIS RAIL
CHICAGO RAIL
60 LBS
WHARTON'S CURVE RAIL
88 LBS
STEAM R R
TRACK
IN CITIES
WHARTON'S CURVE RAIL
JOHNSON
GIRDER RAIL
JOHNSON GIRDER RAIL
SCALE,
FULL SIZE.
PROC. ENG. CLUB.
OF PHILA.
BRAYTON GIRDER RAIL
IN PLACE IN CAST IRON CHAIR

height or thickness, and being rolled in one piece with the rail itself, the whole structure is very firm and strong, both laterally and vertically. The Johnson girder rails are supported in suitable iron chairs, of either rolled or cast iron, and cross-ties of either metal or wood can be used with them. Many miles of tracks have within a few years been laid upon this system in the United States, and the new cable railway on Tenth Avenue and One Hundred and Twenty-fifth Street, New York, is constructed with them. In this case they rest in recesses of the cast iron yokes of the cable conduit, which are placed about four feet apart from centre to centre.

In the Brayton system of girder railway construction, as in use in Providence, Rhode Island, where a number of miles have already been laid or are in process of construction, the depth of the whole rail is seven inches. Cast iron chairs or supports twenty-four inches long, placed seven feet six inches apart from centre to centre, and resting upon concrete foundations, receive and hold in upright position these girder rails. The lower end of the Brayton rail is made somewhat larger than the stem, so that when placed in these chairs and suitable wedges are driven in, the whole structure becomes very firm and solid. Iron tie-rods one and a half inches wide and one-quarter of an inch thick, are placed every seven feet six inches apart from centre to centre. These tie-rods extend through the stem of the rail near the top, and are secured with nuts both inside and outside, thus keeping the rails in a vertical position and preventing the track from spreading. The tie-rods being placed on edge, present no difficulty in paving the street, as they take up but little room.

No allusion has been made in this paper to the construction of cable railway conduits, which form a different branch altogether of the subject, and which might properly come under the head of propulsion or motive power.

VI.

PERTAINING TO ISTHMIAN TRANSITS.

By Preston C. F. West, Member of the Club.

Read March 7th, 1885.

In an editorial in the "Nation" of February 5th, 1885, it is stated that "most of the pamphlets which have been written, and most of the speeches which have been made about the Nicaragua Canal, have so much passion in them of one sort and another, that even their facts and figures can hardly be depended on, much less their conclusions as to its political and commercial importance." This will apply as well to statements that have been made in regard to the Tehuantepec and Panama routes; the article suggests that inasmuch as the defeat of the Nicaragua treaty in the Senate, "offers a little breathing space now," advantage should be taken of it "by a calm and rational view of canals in general."

With this view, I shall be glad to call the attention of the Engineers' Club of Philadelphia, to a subject of so much importance, and avail myself of the opportunity now offered, to embody a few remarks and suggestions, which a personal knowledge of the Darien Isthmus, enables me to make.

I have noticed that in the speeches, as well as the pamphlets, setting forth the relative merits of the three prominent routes, above alluded to, very little has been said about the harbors at their termini, except when the harbors or want of harbors of the rival routes are dwelt upon.

No harbors exist to-day at the termini of the Tehuantepec or Nicaragua routes, sufficient to answer for all the exigencies of inter-oceanic transit, and the conditions existing there are unfavorable in my opinion for their construction, within anything like the period of time, or limit of money, which has been allotted in the reports; at the mouth of the Coatzacoalcos River in Tehuantepec, and at or near Greytown in Nicaragua, harbors are absolutely necessary, before the work of construction inland can be conducted with certainty and despatch; otherwise, the labor

and material, which will necessarily have to be landed at these points, must be sent to the former place, in vessels drawing not over ten or twelve feet, in order to cross a dangerous bar, and landed in a treacherous surf at the latter place.

Aspinwall is sufficiently protected from the prevailing northeast trade winds, but northers which occasionally reach there, have several times played sad havoc with the shipping and wharves; to be secure from such visitations, protection of some kind is needed, which thus far, according to the communication of Capt. Bedford Pim, R. N., to the State Department, dated October, 1884, and published in the "Washington Post" of January 18th, 1884, has been neglected.

Of the three terminal ports on the Pacific, Panama will satisfy the conditions, although much work is needed.

Brito has to be created, as no harbor exists there, and I doubt if the conditions exist, which will admit of a harbor of sufficient capacity being built as proposed.

The exact Pacific terminus of the Tehuantepec route, seems at present to be undecided, but the whole stretch of coast east and west of Ventosa, presents no favorable point for the construction of a harbor of suitable proportions, with any degree of certainty or facility.

Harbors at any or all of the terminal points of the Tehuantepec and Nicaragua routes, would be a great benefit to the commercial world, and the scarcity of harbors on the adjacent coasts, would almost justify maritime powers to assist in their construction.

I would respectfully suggest to the representatives in Congress, that if the Nicaragua treaty comes before them again, with a proviso that four million dollars be paid at once, for internal improvements to meet the new condition of things (as it has been stated is a clause in the treaty), that it should be stipulated this money should be used at Greytown to commence a harbor, so as to enable her in part to deliver goods which she proposes to sell, and does not possess, viz., harbors at Brito and Greytown.

Unlike the construction inland of these Isthmian routes, where in addition to the enterprise proper, provision has only to be made to control the forces of nature, as expressed during occasional rainstorms of more or less violence and volume, the har-

bor construction has to contend with the constant action of the sea and its currents, in all their varying moods and directions, upon sand, rendering any and all works more or less uncertain in their effect and permanence.

The Caribbean Sea, and the Gulf of Mexico, upon which the Atlantic termini (if they may be so called in contradistinction to the Pacific) rest, are not the placid waters that some writers try to make them; for instance, "Captain Silas Bent, of St. Louis," a "practical seaman," and I believe an ex-officer of the U. S. Navy, in an article in the "Scientific American" of Dec. 27th, 1884, is made to say, "the northeast trade winds which extend across the Atlantic, are so broken and interrupted, when they encounter the West India Islands, that they never penetrate the Caribbean Sea; but the northwest portion of them, however, do extend into the Gulf of Mexico, and often so far down as to reach well toward Tehuantepec, so that while in the Gulf, winds are always found, yet the Caribbean remains a region of almost relentless calm."

"Nor is this all, for the mountain ranges extending the length of the Isthmus of Panama and through Central America, offer a still more formidable barrier to the passage of these winds, thus throwing them still higher, into the upper regions of the atmosphere and extending these calms far out in the Pacific Ocean, on the parallel of Panama, with lessening width for fifteen or eighteen hundred miles, to the northwest, along the coast of Central America."

These statements in regard to the Caribbean Sea, do not accord with my experience on it; I have crossed it six times, and have been on its shores ten months, and nearly always found a strong trade wind there, and frequently more than was wanted by ships.

The equatorial calm belt, to the westward of Panama, which is said by some to extend a thousand miles in longitude and sufficient in latitude to include Nicaragua, is worked for all it is worth in favor of Tehuantepec; would it not be well for the Navy Department to send a steamer out through this belt to define its limits and the period of the year that calms prevail, so as to let the world know something more definite about it? I know from

experience, on the Pacific Coast, that sailing vessels can nearly always depend upon a land breeze, blowing off shore after sunset, and a vessel bound to the westward and northward from Panama, can make a respectable passage by hugging the shore, so as to avail themselves of these breezes after nightfall.

As regards the health in these regions, says the author, I would as soon take my chances in one as another; the superior healthfulness of one over another, should not be judged by the experience of small surveying parties in one section, as against large bodies of working men in another; the conditions change when the soil is disturbed, the sanitary organization should be well considered and hospitals established at elevations as well as on the seashore; a little humanity shown in this way, will secure a better class of labor, and a man who recovers from his sickness, is better fitted for the climate than previously.

If bitter feelings are engendered between maritime powers, previous to and during the construction of works of such magnitude, even if they do not jeopardize its successful completion, they are very likely to exist afterward, and will necessitate the expense of arming and watching it, by the naval force of the controlling power, which must be added to the cost of maintenance.

In conclusion, I would call attention to an article in the "N. Y. Sun" of Dec. 12th, 1884, by Prof. J. E. Nourse, who has given a great deal of study to the question of Inter-Oceanic Transits, and his reasonings in regard to mooted points are well worthy of consideration. I would remark, however, that his suggestion, that a commission of army and navy officers be appointed to examine the present status of the question, should be amended by substituting a commission of civil engineers, for the army and navy have had this problem in charge for twenty-five or thirty years, without reaching an accepted solution.

VII.

THE WATER WORKS OF COLUMBUS, GA.

By Jacob H. Yocum, Member of the Club.

Read April 4th, 1885.

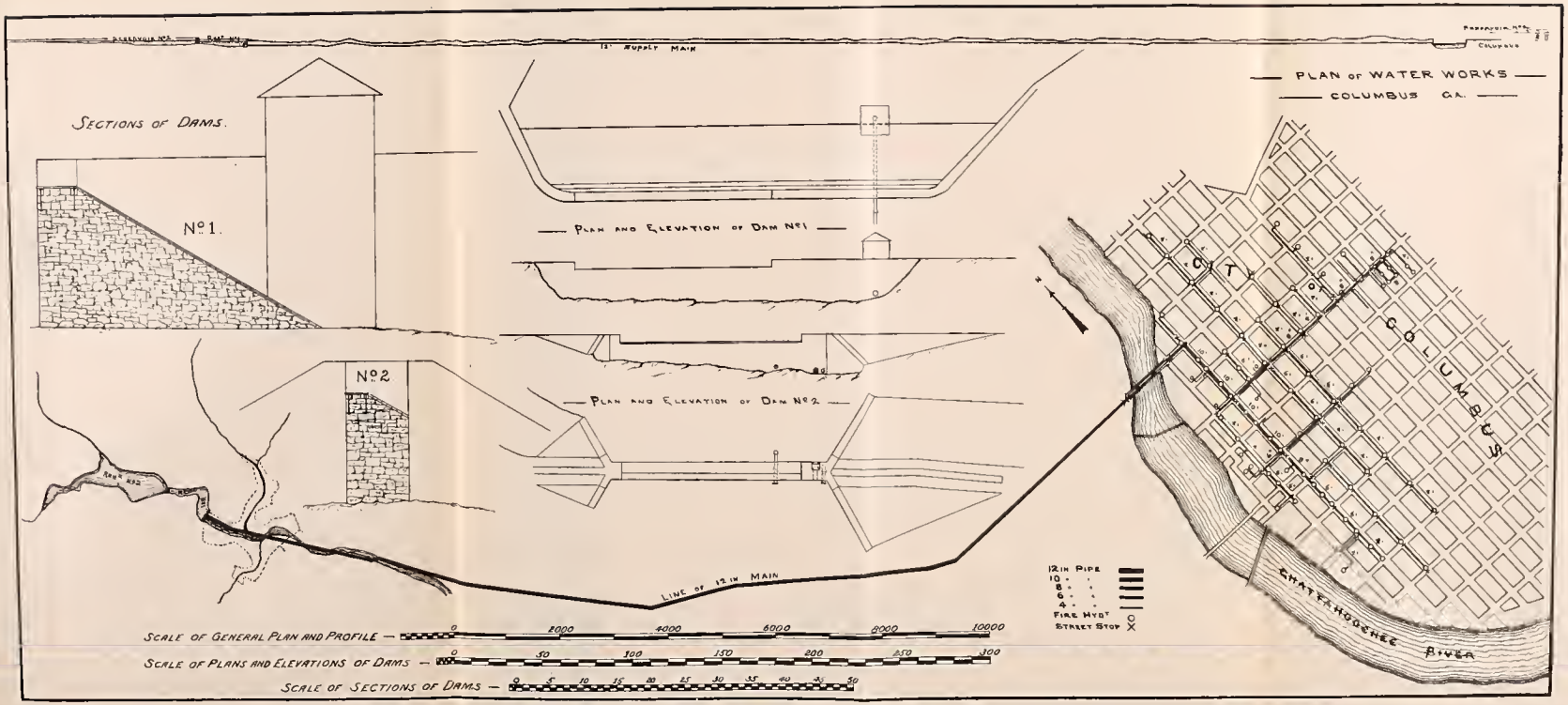
The City of Columbus is situated in the western central portion of the State of Georgia and has a population of about 25,000.

Various surveys of all the sources of water supply surrounding the city were made, and it was at first contemplated to locate the works about four miles directly north of the city and compound one of the feeders to the Chattahoochee River on what is called the Clap Farm, and build a reservoir holding from 120,000,000 to 150,000,000 gallons and deliver it to the city under a head of 108 ft. through a 12-in. main, and then distribute as needed through various size pipe, from that size down to 4-in., but from various causes this project was abandoned, and a second location procured and the works completed as they now are. This is in a northwestern direction from the city and in the State of Alabama, on what is called the McElvey Farm, and which covers the site of an old mill dam constructed many years ago, but which was destroyed by a water spout.

This site involved the crossing of the Chattahoochee River directly west of the city, about 800 ft. wide, and which was proposed to be done by a submerged main, but for which were afterward substituted two 9-in. wrought iron pipes, crossing the upper bridge of the city, as shown by plan No. 1.

The Chattahoochee was investigated as a source of supply, but being subject to heavy freshets and highly impregnated with clay at all seasons of the year, giving it a yellow appearance and which would require expensive filters to get it in a drinkable state and heavy machinery to pump it to the reservoirs for distribution, it was estimated to be more costly than the gravitation system which we have adopted.

Among the hills of Alabama we found the water pure and soft, delivered through the gravel beds and a gathering ground covering over twelve square miles, which would give us when allowing one-half for absorption and evaporation a daily supply of 15,000,000 gallons.


PLAN OF WATER WORKS
COLUMBUS GA.
SECTIONS OF DAMS.
No. 1.
No. 2.
PLAN AND ELEVATION OF DAM No. 1
PLAN AND ELEVATION OF DAM No. 2
12" SUPPLY MAIN
LINE OF 12 IN MAIN
CITY OF COLUMBUS
CHATTAHOOCHEE RIVER
12 IN PIPE
10 " "
8 " "
6 " "
4 " "
FIRE HYDT
STREET STOP
SCALE OF GENERAL PLAN AND PROFILE — 0 2000 4000 6000 8000 10000
SCALE OF PLANS AND ELEVATIONS OF DAMS — 0 50 100 150 200 250 300
SCALE OF SECTIONS OF DAMS — 0 5 10 15 20 25 30 35 40 45 50

The first reservoir constructed on the McElvey Farm was about 20,000,000 capacity, and was made by throwing a stone dam across a ravine some 250 ft. wide. This dam was built in the old-fashioned style (as shown in drawing No. 2) of stone blasted from the reservoir directly back of it. This stone was laid in lime mortar. The front of the dam is 21 ft. with a parapet wall 4 ft. high and 6 ft. wide running over the top. The inside slope is two to one, and upon it was placed two courses of brick in hydraulic cement.

On the inside of the reservoir is a square filter house 16 ft. each way, in which is a filter packed with charcoal, and from which a 12-in. main is laid to the city under a mean gradient of six-tenths of a foot to every hundred.

Above the first reservoir is a second constructed by throwing a stone dam across a ravine 266 ft. wide and covers some twenty acres and contains about 100,000,000 gallons. This dam is 21 ft. high with weir 100 ft. wide and abutments and slope walls at each end, and four and six feet dyke walls running from these each way to fast land.

All of these walls are built with stone in hydraulic mortar, making one homogeneous mass. On the inside and outside of these dyke walls were made embankments of clay and gravel in layers of about 4 in. The clay being placed next to the walls and the looser material outside, and each course tamped when placed. The inside slope was faced with spalls from the quarries just inside of the reservoir, and the outside slope was covered with black earth and Bermuda grass.

The entire stone work of dam was pointed with hydraulic cement, and every loose rock removed from foundation, and all crevices grouted before a stone was laid, and we have the pleasure of securing a perfectly tight dam.

By referring to drawing No. 2, some idea may be obtained of the form. It is square built, 9 ft. thick with the top face at a distance of 3 ft. back, sloped one to one, and on this slope one course of brick on edge are set in hydraulic cement, and on the top is a flooring of 3-in. pine plank fastened to heavy square timbers walled in and anchored with heavy bolts to the stone work.

The dam is fitted with three gates of wood, two inside and one

outside; the inside ones being telescopic. The upper one is used to supply the water from the surface of the reservoir for drinking, while the lower one is to be used only to empty the reservoir. These gates open into a centre passage which is guarded by the outer gate and leads into the lower reservoir.

This insures the aerating the water when passing from one reservoir to the other, the same as when it passes over the weir.

The land flooded by the reservoirs was originally a forest of timber and cane with the water breaking its way through them, and this was all felled and every stump and vestige of timber grubbed out and the muck removed, leaving the sand and clay for the water to rest upon and insuring its purity.

The supply main from the reservoirs to the city is 18,009 ft. long and 12 in. diameter. When it gets to the Chattahoochee it is divided into two 9-in. wrought pipes, and is run each side of the bridge underneath the floor girders and then unites again on the city side to a 12-in. cast iron pipe and to the distribution, as shown by drawing No. 1, composed of 10, 8, 6 and 4-inch cast iron pipe, which are fitted with the Cassin double fire hydrant and the necessary stop cocks.

The first reservoir is 115½ ft. above the centre of the city, and the second 130½ ft. above.

By connecting a hose to the fire hydrant a one-inch stream can be thrown 85 ft. perpendicular, and in the opening test we threw seven streams 75 ft. at the same time.

The work of constructing No. 1 reservoir, the 12-in. supply main with five miles of distribution, was commenced in April, 1882, and finished on the 26th of October of the same year.

The No. 2 reservoir was commenced the 21st of January, 1884, and finished July 11th.

It is proposed to lay a submerged main in the Chattahoochee this year and do away with the 9-in. pipe on the bridge.

These works have stood a drought of over four months last year, and had an abundance of pure good water.

Columbus has quite a large manufacturing interest, and has made drafts upon our works beyond our expectations for so short a time. We have looked considerably to the future and made surveys for a large reservoir to hold some 400,000,000, as shown by dotted lines, drawing No. 1.

WILLIAM LORENZ.

Although I knew the late William Lorenz well, for fourteen years, and many of my friends have known him more intimately for a much longer period, yet not one of us is familiar with his personal history. His modesty and reticence would not allow him to dwell upon himself, lest he might annoy his friends and acquaintances with matters that concerned himself only. He was born in Osnabrück, in the Province of Hanover, Germany, on the 23d of December, 1826. He received a thorough classical and technical education, graduating from the Polytechnic College at Hanover, where he was a classmate of August Ritter, the writer of the well-known treatise on the Theory of the Construction of Roofs and Bridges.

After working in a machine shop for several years, making himself familiar with the actual practice of mechanical engineering, Mr. Lorenz came to America, on a leave of absence from the Hanoverian Government, to study the method of railroad construction in this country. As his brother was then already established in commercial business in New York, he had no difficulty in becoming acquainted, and his own sterling qualities soon won him friends.

Mr. Lorenz at first superintended the construction of some locomotives at the old "Novelty Shops," but very shortly after his arrival in the United States he came to Philadelphia, and presented his letters of introduction, one of them to the late Mr. J. Tucker, then President of the Philadelphia and Reading Railroad Company. This letter procured for Mr. Lorenz a position as topographer, on the Lebanon Valley Railroad, the location of which was then being made, and from that day until his death, on the 29th of December, 1884, he remained in the service of the P. & R. R. Co., being its Chief Engineer for the last twelve years.

The first work of importance given to Mr. Lorenz by Mr. J. D. Steel, then Chief Engineer of the P. & R. R. Co., was the preparation of a map of the canals and railroads for transporting anthracite coal from the different coal fields to New York. This map was published in 1856, and, on account of its great accuracy, is

to-day the basis of all maps subsequently made, embracing that territory. The completion of this map necessitated an enormous amount of work in the field and in the office, and all of it was performed under Mr. Lorenz's direct supervision, or by himself personally. As he was an accomplished draughtsman, and very fond of drawing, he finished the whole map himself. While engaged in the anthracite coal field, on these surveys, he frequently came in contact with parties engaged on the first geological survey of this State, and valuable and great was the assistance he rendered them; so much so that his help was officially recognized and rewarded.

In 1861 Mr. Lorenz was transferred from the Pottstown to the Lebanon Residency, as Engineer of the P. & R. R. There, the only partially developed, enormous and valuable ore-beds of the Coleman Estate, together with the sudden impetus given to the iron trade by the Civil War, gave Mr. Lorenz an opportunity to display his thorough knowledge of geology, mineralogy and mechanics, and to make it of practical use to his many friends in the iron business.

He designed, located and constructed the spiral railroad around the iron mountain, of conical shape, at Cornwall, near Lebanon, which enabled the owners to mine the immense masses of ores there deposited to the greatest advantage and at a minimum cost.

In 1867 Mr. Lorenz first introduced, on the Lebanon Valley Railroad, the pointed safety switch which now bears his name, although he never had it patented, and utterly disclaimed the idea of being the inventor of it. He had known the switch in Europe, and was convinced of its superiority over anything in this country, and with the permission of the P. & R. R. Co., he introduced it with valuable improvements, on the road. There is no doubt Mr. Lorenz could have received a patent, and could have made much money by it; but such a transaction was foreign to his nature, and I am sure he never gave it a thought.

In the fall of 1872, after the death of Mr. C. E. Byers, Mr. Lorenz became Chief Engineer, and retained that position until his death.

The rapid development of the P. & R. R. R. system during these years, threw upon its Engineering Department an enormous

amount of labor, requiring good judgment and a technical knowledge of infinite variety: the construction and maintenance of railroads; of bridges, depots and other buildings; of wharves, coal depots and grain elevators; of ship-yards, dry docks and ocean piers. All of the plans and designs, as executed, were subject to his approval, and all of them bear the stamp of his knowledge and skill.

Every member of his large staff was treated by Mr. Lorenz, at all times, with impartial courtesy and patience; the latter virtue being sometimes carried to excess, because there were always some men ready to take advantage of it to their own profit.

Mr. Lorenz justly enjoyed the complete confidence of the P. & R. R. Co., as his sound judgment, expressed only after calm deliberation—but then with great firmness—could always be relied upon. His clear mind, stored with knowledge acquired by years of hard study and by constant intercourse with prominent men, was aided by a marvelous memory, which enabled him to retain all he ever read or saw, and use it at the proper moment. But his natural modesty and calmness covered, to a great extent, his ability and learning from the world, only to come out so much stronger in the presence of those familiar with him, or before those who had retained his services.

Socially Mr. Lorenz was the kindest, truest, and the most genial of gentlemen. He would never sit in harsh judgment upon his fellow-men, although his honest and pure life made him detest sin in all its shapes. He had numerous and sincere friends, and they all enjoyed thoroughly the occasion when Mr. Lorenz could throw aside his impenetrable calmness and relate, in his own and thorough way, one of his numerous anecdotes, always full of wit and never offensive.

The death of his eldest son, at the age of twenty, some three years ago, affected Mr. Lorenz so deeply that he was never thoroughly himself again. All his pleasures and hopes seemed to be centred in that boy, who was, almost in everything, like his kind, his generous, his noble father.

CHAS. W. BUCHHOLZ.

ARTHUR ROBERT FAUNT LE ROY

Was born in New Harmony, Indiana, in the latter part of 1843; he died in Milwaukee, Wisconsin, on the morning of December 16th, 1884, of disease of the heart. He was the youngest son of Robert Henry Faunt Le Roy, of Virginia, who was distinguished in the service of the United States Coast and Geodetic Survey for his high mathematical attainments and great mechanical abilities. The father died in 1850, when on duty in the triangulation of the coast of Texas.

The eldest brother of the family died in the service of the Coast and Geodetic Survey in California in 1859.

Mr. Faunt Le Roy's mother was the daughter of the well-known philanthropist, Robert Owen, of New Lanark, Scotland, who abandoned his immensely lucrative business to make a trial of his social theories in America in 1824.

After the death of his father in 1850, his mother, having herself been educated in Scotland and in Germany, determined to take her family to the latter country to receive the thorough groundwork of a mathematical education for the two sons and music and languages for the two daughters. The family being young, traveled under the protection of their uncle, Hon. Robert Dale Owen, then (1852) appointed Minister to Naples. The family settled at Stuttgart, and here young Faunt Le Roy naturally fell into habits of study as well as reserve. He became a thorough German and French scholar, and was well-grounded in mathematics and mechanics. His vacations were spent by the brothers and sisters in trips through various parts of Europe, and when he returned to the United States in five years he appreciated the need for practicable application in the workshop. He left his home and placed himself in one of the largest mechanical workshops in Philadelphia, pursuing his daily labor with great industry and interest. After returning home he gave much time to study and to practical work on the stationary engines around the country and the engines on the river boats. On one of these boats he exhibited his presence of mind and promptness of action in drawing the fires when in a position of great danger, and was commended for his coolness and courage.

Sometime after the death of his brother he was appointed by Prof. Bache as an aid on the U. S. Coast and Geodetic Survey, and during the Rebellion he did service in the examination of the channels and approaches to Wilmington, Charleston, Savannah, etc. At the latter place, when reconnoitring with an unarmed boat's crew in thick, hazy weather, he suddenly came upon a large schooner coming out of one of the (to us) unknown channels leading from the Savannah River. He promptly rushed his boat for the vessel. Her crew left her on one side as he and his men clambered up the other and held her as a prize.

At the close of hostilities he was engaged in the dangerous duty of searching the different channels for torpedoes.

In a short time after this he remained at Germantown with his brother-in-law, Prof. George Davidson, then on special duty, and in order to fit himself for the highest branches of civil engineering, he obtained leave of absence and devoted himself to the mathematics of mechanics, especially as applied to hydraulics, and railroad and bridge building. Several tempting offers failed to draw him away from his self-prescribed plans, and when they were completed he received a position as an Assistant Engineer on the Philadelphia and Reading Railroad Company, and by his ability and integrity won the highest confidence and esteem of the officers of that great corporation. In every emergency that arose he was ever prompt, ready and successful in the practical direction and execution of all repairs and replacements in the largest damages. In 1873 he was intrusted by them with the construction of their immense coal depots along the northern Atlantic seaboard ports. In these works, where he was not only the designer and superintendent of construction, but also the disburser of enormous sums of money, his health began to fail.

After taking a year's rest he again engaged in railroad and bridge engineering and construction on the St. Louis and South Eastern Railway (now the Louisville and Nashville), building, notably, the bridge over the Wabash, which has been pronounced by competent authority one of the safest and most substantial wooden bridges on the Continent. It is said that this was the only bridge that withstood the great freshets when very many others were carried away in the same region.

He was frequently offered leading and important positions, but he never would accept one when his duty as a constructor, especially of bridges, would be hampered or jeopardized by the interference of higher officials or contractors.

With failing health he sought some relief from the exposure of field work, where the heaviest duties came at inclement seasons, and hence for several years he was engaged under General Weitzel, of the United States Corps of Engineers, with Mr. Powers, in the construction of the magnificent locks at Sault St. Marie.

With his thorough mathematical and mechanical training, both theoretical and practical, we should have heard much more of his work, had he possessed a robust constitution. So far as we can gather from his extensive range of professional friends, he never made a mistake in his work. The text-books of his earlier studies are marked throughout with corrections to the formulæ, or with simplifications for practical application. This thoroughness was a trait of both his father and mother; the former when a young man had mastered the whole of Young's mathematical course, involving the differential and integral calculus, etc., without a teacher or adviser.

Mr. Faunt Le Roy was quiet, reserved and studious; singularly pure and high minded in character. Only in the society of very intimate and cherished friends did he show what his powers were. In the social circle he sometimes "came out of his shell," as his confrères expressed it, and then his conversation sparkled with wit and the driest and drollest humor, coming back quickly to grave applications which exhibited his keen mental culture and vision. He had won the confidence and the respect of his associates, both superiors and subordinates, by his unswerving uprightness and justice; by his courteous appreciation of the capacity of others, and by his gentleness of manner. Letters from very many of his friends from all parts of the country where he had labored testify to the esteem and affection in which he was held, and the urgency of several of them has compelled the writing of this brief and insufficient memoir.

For some months before his death he had been at work in the office of Mr. D. J. Whittemore, Chief Engineer of the Chicago, Milwaukee and St. Paul Railway, and although we were aware

of the frailty of his health, he never uttered a word of warning that he was seriously affected. The affection of those around him was very touching, and one who had known him intimately, wrote that "he has left a character without a blemish."

After a short service at Milwaukee, which was attended by the friends and employés of the Engineering Department of the Chicago, Milwaukee and St. Paul Railway in a body, the Rev. Dr. Runcie, Rector of Christ Church, St. Joseph, Missouri, brother-in-law of the deceased, accompanied by an escort of honor from the Engineering Department, started for the family burial place in New Harmony, where services were again held, and the whole town closed their doors and bore the body of their beloved townsman to place it by the side of his father, mother and brother.

Mr. Faunt Le Roy was within a few days of his forty-second birthday and was never married. E. D.

San Francisco, Cal., 1885.

DAVID HUDSON SHEDAKER

Was born in Philadelphia, June 9th, 1823, and received his early education in the schools of his native city.

In the construction of the Pennsylvania Railroad, 1847–50, he was employed successively as chainman, rodman and assistant engineer, and in the latter year was appointed engineer in charge of the widening of the Susquehanna River Bridge at Columbia. In 1850–51 he had charge of the drainage and sewerage of Philadelphia (old city). 1851–53 he was Chief Engineer in the construction of the Chester Valley Railroad. In 1853 was appointed assistant to the Resident Engineer, Pennsylvania Railroad, leaving that to become Assistant City Surveyor of Philadelphia (old city). Under the act consolidating the City of Philadelphia, he was elected by Councils as one of the Surveyors and assigned to duty in the First Survey District. He served in this position but

one month on account of a change in the law governing the election of surveyors. From that time he was engaged in his profession as engineer and surveyor in various localities, until 1857, when he was called upon to take charge of the Third Survey District. In May, 1860, he was elected by the people as the Surveyor of that District and was subsequently re-elected in 1865, 1870, 1875 and 1880, for periods of five years each. During this time he was engaged in various works outside his duties as surveyor; being the Engineer of the Girard Estate in the City of Philadelphia, continuously since 1870. He was also the Engineer in charge of the construction of the River Front Railroad. He died on Thursday, February 5th, 1885. Mr. Shedaker was thoroughly in love with his work; he was more of the practical than the theoretical, yet was not wanting in the necessary theory. To discharge the duties of the office of Surveyor of the Third District, embracing, as it does, the old city, where are located the most valuable properties, required a man of good sound judgment, with a knowledge of the laws and decisions relating to property lines. Standing as he did as umpire between the various parties, he was obliged to study well the case, as his decision, if wrong, might be productive of tedious and expensive litigation. How well he performed his duties and with what satisfaction to the people, is evidenced by his election and re-election for four successive terms. He was warm in his friendship, kind and courteous in his intercourse with his fellows, honest and upright in all his dealings, a good citizen and a kind friend. He has finished his work and gone to his rest. Peace to his ashes.

John H. Dye,
Jas. R. McClure, } *Committee.*
Jos. Johnson,

FROGS AND SWITCHES.

ROBERT P. SNOWDEN, November 15th, 1884.

The number of a frog is the altitude of an isosceles triangle, whose vertical angle is the frog angle and whose base is unity.

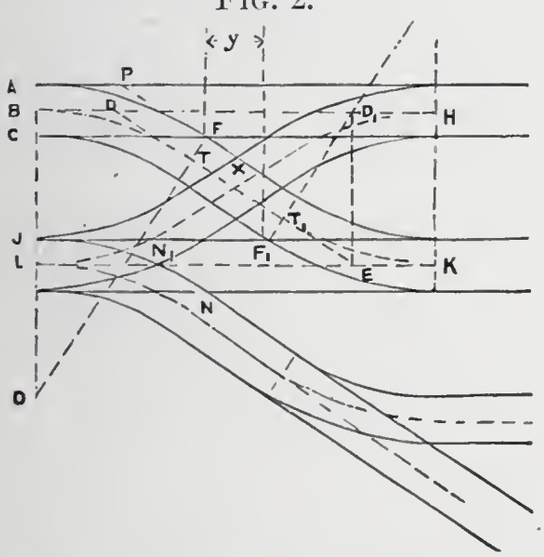
FIG. 1.

$AC = 1.$
$DB = n.$

In Fig. 1, if $ADC =$ frog angle, then the altitude DB is the number of frog. The side AD is sometimes incorrectly taken as the number of frog.

Some of the following formulæ are common property, for others I am indebted to Mr. J. A. Anderson, Supt. Belvidere Division, Pennsylvania Railroad, and others are my own.

FIG. 2.



$n =$ number of frog.

$CA = g =$ gauge.

$BO = R =$ radius of centre line.

$CJ = S =$ distance between gauge lines.

$D_1 E = W = S + g =$ distance between centre lines.

$CF = D =$ frog distance or lead.

$TT_1 = t =$ tangent between frogs.

$LN_1 = D_1 =$ distance or lead to crotch frog.

$n_1 =$ number of crotch frog.

(1) $D = 2\,gn.$

(2) $= \sqrt{R \times 2g}$

(3) $R = 2\,gn^2$

(4) $= n\,D$

(5) $= \dfrac{D^2}{2g}$

(6) $g = \dfrac{D^2}{2R}$

(7) $n = \dfrac{\sqrt{R \times 2g}}{2g} = \sqrt{\dfrac{R}{2g}}$

(8) $BD = gn$

(9) $AP = g\left(\dfrac{n^2 + \frac{1}{4}}{n}\right)$

(10) $DE = W\left(\dfrac{n^2 + \frac{1}{4}}{n}\right)$

(11) $DD_1 = W\left(\dfrac{n^2 - \frac{1}{4}}{n}\right)$

(12) $TT_1 = t = W\left(\dfrac{n^2 + \frac{1}{4}}{n}\right) - 2\,gn$

(13) $BH = W\left(\dfrac{n^2 - \frac{1}{4}}{n}\right) + 2\,gn$

(14) $y = W\left(\dfrac{n^2 - \frac{1}{4}}{n}\right) - 2\,gn$

(15) $D_1 = g\sqrt{2\,n^2 + \frac{1}{4}}$

(16) $n_1 = \dfrac{n^2}{\sqrt{2\,n^2 + \frac{1}{4}}}$

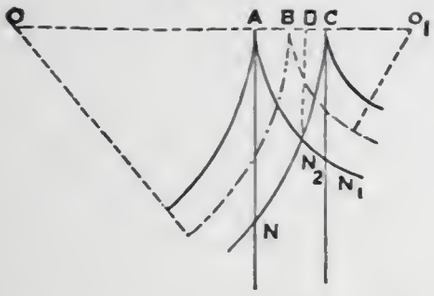
(17) $n_1 = \dfrac{\sqrt{R \times g}}{2g}$ approx.

(18) $n_1 = \frac{1}{2}\,n\sqrt{2} = \sqrt{\frac{1}{2}\,n^2} = .707\,n$ approx.

(19) Frog number at X for X crossing $= \dfrac{n^2 - \frac{1}{4}}{2\,n}$

(20) Its distance from nearest gauge $= \dfrac{W}{2} - \dfrac{g\,n^2}{n^2 + \frac{1}{4}}$

FIG. 3.



$OB = R$
$O_1B = R_1$
Frog number at $N = n$
" " " $N_1 = n_1$
" " " $N_2 = n_2$

(1) $BD = \frac{g}{2}\left(\frac{R - R_1}{R + R_1}\right)$

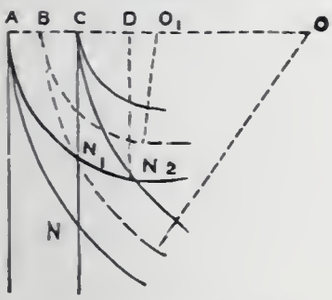
(2) $DN_2 = \dfrac{2\sqrt{\frac{g\,RR_1}{2}\left(R + R_1 + \frac{g}{2}\right)}}{R + R_1}$

(3) Arc $CN_2 = 2\,gn_2$ approx.

(4) $n_2 = \dfrac{nn_1}{\sqrt{n^2 + n_1{}^2 + \frac{1}{4}}}$

(5) $n_2 = \sqrt{\dfrac{RR_1}{2g\,(R + R_1)}}$ approx. $= \sqrt{\dfrac{n^2\,n_1{}^2}{n^2 + n_1{}^2}}$ approx.

FIG. 4.



$OB = R$
$O_1B = R_1$
Frog number at $N = n$
" " " $N_1 = n_1$
" " " $N_2 = n_2$

(1) $BD = \frac{g}{2}\left(\frac{R + R_1}{R - R_1}\right)$

(2) $DN_2 = \dfrac{2\sqrt{\frac{g\,RR_1}{2}\left(R - R_1 - \frac{g}{2}\right)}}{R - R_1}$

(3) Arc $CN_2 = 2\,gn_2$ approx.

(4) $n_2 = \dfrac{nn_1}{\sqrt{n^2 - n_1{}^2 - \frac{1}{4}}}$

(5) $n_2 = \sqrt{\dfrac{RR_1}{2g\,(R - R_1)}}$ approx. $= \sqrt{\dfrac{n^2\,n_1{}^2}{n^2 + n_1{}^2}}$ approx.

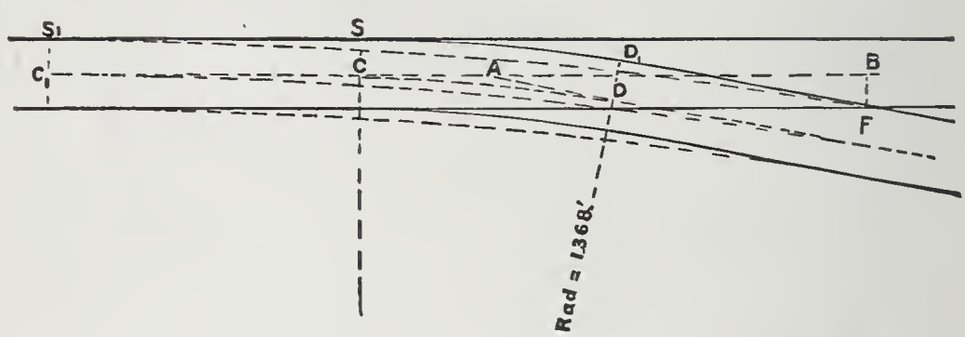
There are several points that should be considered when putting in switches. Theoretically, the lead for say a No. 8 frog is 76 feet. Practically, it should be less than this when using any other than a stub switch. The thickness of the point of a switch is always appreciable. Say it is one-quarter inch, then the point of the switch should be set back of the theoretical point 5 feet as given by the formula·

$$D = \sqrt{R \times 2\,g}$$

substituting for g, the width of the point of switch. For No. 10 frog, this distance will be 6.29 feet, and for No. 12 frog, 7.5 feet if the point be one-quarter inch thick.

The heel of the switch should not be set closer to main rail than 3 inches. Now, then, if a longer frog than No. 12 be used, the lead should be composed of a curve of 1,368 feet radius (corresponding to a No. 12 frog) and a tangent through the frog.

Fig. 5.



Find AB by formula $= gn$,

Then $CA = AD = \dfrac{R\ (= 1368)}{2\,n}$ and C and D are the tangent points of the curve. The part D_1F of lead is a tangent.

For example, take a No. 20 frog. C_1B would be the

lead by formula $D = 2\ gn$, but in practice it will be found to be impossible to make a good lead if we put the switch so far back, consequently we should compound the curve, or, better, make part a curve and part a tangent, as follows:

$$AB = g\,n = 4.75 \times 20 = 95$$

$$CA = AD = \frac{R\ (= 1368)}{2\,n} = \frac{1368}{40} = 34.2.$$

From point of switch to point of frog $95 + 34.2 = 129.2$. But the point of switch should be set back on account of thickness of point. If one-quarter inch thick, the formula gives 7.5 feet.

$$D = \sqrt{R \times 2\,g} = \sqrt{1368 \times \tfrac{1}{24}} = 7.5 \text{ feet,}$$

then $129.2 - 7.5 = 121.7$ = actual frog distance.

The above formulæ may be used in several ways. For instance, instead of laying off lead by eye as is generally done, offsets for points on curve may be found by formula $g = \frac{D^2}{2\,R}$ making D = distance from origin of curve to point where offset is desired.

If it be desired to find the point where a curve shall originate to become parallel with tangent at a given distance from it, the formula $D = \sqrt{R \times 2\,g}$ can be used making $2\,g$ = distance between parallel tangents, D will be the distance along tangent to a point opposite reversing point and $2\,D$ will be distance to point opposite tangent point on parallel tangent. There will be no short tangent between curves in this case.

It is well to remember in running curves that the square root of the radius in feet is the length of a chord, whose deflection is one foot.

FORMULÆ FOR TWO SIDES AND INCLUDED ANGLE WHERE LOGS. ARE USED INSTEAD OF DISTANCES.

S. C. McCorkle, July, 1885.

$45° - \text{tangent}\ (a - b) = \alpha.$

$\text{Tangent}\ \alpha + \text{cotangent}\ \tfrac{1}{2}\ C = \text{tangent}\ X.$

$X + (\tfrac{1}{2}\ C - 90°) = \text{larger angle.}$

$X - (\tfrac{1}{2}\ C - 90°) = \text{smaller "}$

Examples.

Log. (b)	3.384802
" (a)	3.855382
Tangent	9.529420 = 18°41′43″.5

	C. ° ′ ″	
< 2)	147 58 34.16	
$\tfrac{1}{2}$ C	73 59 17.1	
	—90 00 00.0	
$\tfrac{1}{4}$ C —90°	16 00 42.9	
	8 04 26.4	
	7 56 16.5	—
	24 05 09.3	+

	° ′ ″	
	45 00 00.0	
	—18 41 43.5	
	26 18 16.5	α.

Tangent α	9.694017	
Cotangent $\tfrac{1}{2}$ C	9.457837	
	9.151854	Tan. 8°04′26″.4

		° ′ ″	
< at	C	147 58 34.16,	observed.
	B	24 05 09.3,	computed.
	A	7 56 16.5,	"
		180 00 00.0	

The shape of the triangle is immaterial, although in computing the distances a right angle, or equilateral triangle is best.

The above is not original.—S. C. McC.

NOTES AND COMMUNICATIONS.

A PORTABLE STORAGE BATTERY FOR MINING AND EXPLORING PURPOSES.

Regular Meeting, October 18th, 1884.—Mr. C. Henry Roney showed a battery, with small incandescent lamps, illustrating his remarks with blackboard sketches. The battery shown was a modification of Planté's, devised by Dr. E. T. Starr, of Philadelphia, the electrodes consisting of V shaped plates of sheet lead arranged over each other, the convexity downwards, with a slight interval between them, their ends attached to a lead frame by "burned" joints, the interstices between the plates being filled with finely divided metallic lead, exposing a large surface to oxidation and reduction when subjected to dynamic electric or voltaic energy, and, in turn, giving off a large percentage of the "stored" energy to incandescent lamps placed in the circuit. The battery shown measnred 3¼ inches long, 2¾ inches high, and ¾ inch thick, and would maintain a small two-candle incandescent lamp at incandescence for about one hour. A battery sufficiently large to run an eight-candle lamp for ten or twelve hours would not be too large or heavy to carry conveniently for mine or other underground exploration.

AN INDICATOR.

Regular Meeting, October 18th, 1884.—Mr. Wm. L. Simpson exhibited and described the Thompson indicator. He considers it handsome in design, and convenient and simple in arrangement. Cards can be taken with it at as high a pressure as 500 lbs. per square inch. All the moving parts are made very light and strong, which is a consideration of much importance in an indicator, especially when used on engines traveling at a high rate of piston speed. The coiled spring within the paper cylinder, for increasing or decreasing the tension for different speeds of engines, is so arranged that as little or much of it can be taken up as may be desired. This is quite an improvement, as, formerly, a whole coil of the spring had to be taken up or none at all. By means of a jamb-nut the horn handle screw can be set so as to regulate the pressure of the pencil on the paper, the back of the screw touching against a small post, and thus avoiding any strain tending to throw the parts out of line through too much pressure. To exchange springs is very easy, it only being necessary to unscrew the milled nut at the top of the steam cylinder, take out the piston with its arm and connections, disconnect the lever and piston by unscrewing the small knurled-headed screw which connects them, when the spring can be removed from the piston and the desired one substituted.

All springs made for this indicator are scaled, providing for 30 inches vacuum; and the capacity of any spring can be ascertained by a simple rule. To adapt the Thompson indicator to all pressures, springs can be made to any desired scale. The following are the most generally used: 8, 10, 12, 16, 20, 24, 30, 32, 40, 48, 50, 56, 60, 64, 80, 100. For pressures from 65 to 85 lbs. a 40 lb. spring is best adapted, for as 40 lbs. pressure on a 40 lb. spring will raise pencil one inch, 85 lbs. pressure on the same spring will raise pencil about two inches, which is the usual height of a diagram.

By means of the "detent motion," consisting of a pawl and spring stop, the paper cylinder can be stopped and the card taken off without unhooking the connecting cord. An arrangement of a swivel carrying a scored wheel allows the connecting cord to be run at any angle, so that it is possible to connect with any motion, of whatever kind, wherever it may be.

FIRE PROTECTION IN MILLS.

Regular Meeting, October 18th, 1884.—W. Bugbee Smith presented notes upon this subject. Mills must be properly built and furnished with adequate fire extinguishing apparatus. The best construction has been found to consist of heavy wooden posts and girders, solid plank floors and roof. The usual fire extinguishing apparatus consists of water buckets, hydrants and hose. In addition to this some mills are furnished with perforated sprinkler pipes, running lengthwise through the mill, perforated with holes $\frac{1}{10}$ inch diameter and about nine inches apart. In case of a fire, by opening a valve outside of the building, water is let into the pipes and on the fire. The objection to this system is the fact that the water is not confined to the spot where the fire occurs, but is distributed over such a large area that much damage is done by it. It also requires human agency to make it effective.

To overcome these objections automatic sprinklers have been invented. These are valves, placed on a system of pipes near the ceiling and opened by the heat of the fire. They are kept closed by means of a fusible solder which melts at about 166° Fahr. The heat rising from a fire melts the solder joints of the sprinkler immediately over it, and thus the water is put just where it is needed.

There are two general classes of automatic sprinklers, the sealed, such as the Parmelee, Burritt, Rose and Bishop; and the sensitive, such as the Grinnell, Burritt, Brown & Hall, and the Kane. After describing the methods of piping a mill for each of the classes, samples of the above mentioned sprinklers were exhibited and their peculiarities explained.

The automatic sprinklers have been in use about twelve years, and recent tests show that the fusible solder has not lost its strength and sensitiveness in that length of time, though exposed to pressure and water hammer.

The effectiveness of automatic sprinklers as fire extinguishers is shown by the fact, that out of 110 fires originating under them and of which the damage is known, for 67, or 60.9 per cent. of the whole number, no damage was claimed; for 12, or 10.9 per cent., the damage was less than $250; for 8, or 7.2 per cent., between $250 and $500; for 11, or 9.9 per cent., between $500 and $1,000; for 12, or 10.9 per cent., between $1,000 and $20,000.

The Secretary exhibited, for Mr. S. L. Smedley, a photo-lithographic reproduction of a topographical Map of Philadelphia, by John Hills, 1796, and pointed out some of the remarkable evidences of its great accuracy in detail.

MR. WILLIAM ASTOR'S STEAM YACHT.

Regular Meeting, November 15th, 1884.—Mr. John Haug presented a description, illustrated by drawings and test specimens, of Mr. William Astor's new Steam Yacht, the first sea-going steamship built of steel in this country. She is 235 ft. long on load water line, 30 ft. beam, and 20 ft. deep, and has two complete decks of

¼ in. steel plates. Her machinery consists of a compound engine with cylinders 34 and 60 ins. diameter and 36 ins. stroke, supplied with steam of 85 lbs. pressure by four oval boilers built of steel, and having 170 sq. ft. grate surface and 4200 sq. ft. heating surface. Her hull and machinery have been arranged according to Lloyd's rules for a class of 100 A 1, and she has been specially surveyed while building. Lloyd's rules for steel vessels require a material having a tensile strength of not less than 27 nor more than 31 tons per sq. in., having an extension of not less than 16% in a uniform length of 8 ins. Steel of greater tensile strength has been found proportionately deficient in ductility. The plating for the above vessel, supplied by the Danville Iron and Steel Company, of Danville, Pa., was found to be of very good quality, the tensile strength varying from 62,000 to 72,000 lbs. per sq. in., the extension (in 8 ins. length) from 20 to 24% as shown by several samples. Some samples showed as high as 90,000 lbs. tensile strength, but the extension was only 6 to 10%, rendering it unfit for use. The steel for the boilers was also of superior quality; one test piece, cut diagonally from a plate, showed no difference from others cut lengthwise. A test piece with punched hole broke at 57,000 lbs., while one with a drilled hole broke at 61,000 lbs., showing less difference than is generally supposed. Some pieces, bent double, after having been heated and quenched in water, showed a remarkable softness and ductility. The material for the frames and beams of this vessel was supplied by the Pencoyd Iron Works, and fulfilled the requirements of the rules, as shown by numerous test pieces.

THE STEAM YACHT "MAGNOLIA."

Regular Meeting, November 15th, 1884.—Mr. Fairman Rogers described his Steam Yacht "Magnolia," built in 1882, by the Herreshoff Manufacturing Company, Bristol, Rhode Island. The following conditions were required to be fulfilled in her design: Light draft, not more than 4 ft., length and breadth such as to enable her to pass through the Erie Canal locks, which are 100 x 18 ft., flat floor, large accommodations for cruising and for a long residence of the owner's family on board, flush deck, no projection of steam drums, etc., above deck, except the smoke-stack. Low speed, not less than 8 miles per hour. Minimum head room below, 6 ft. 6 ins. Adapted specially for inland cruising along the Atlantic coast. She turned out to be entirely satisfactory. Her ordinary speed is 10 miles, maximum 11½ miles. She has twin screws 36 ins. diameter, 50 ins. pitch, two compound condensing engines, 6 ins. and 10½ ins. x 10 ins.—45 lbs. steam, 270 turns per minute. Two flat coil square boilers. Entire motive power weighs five tons. Consumption of coal (anthracite) 165 to 200 lbs. per hour. Carries 15 tons. She is schooner rigged and sails six knots dragging her screws. Bent oak frames, 3 ins. x 3 ins.; yellow pine planking, 2⅜ ins.; white pine deck, 2 ins.; mahogany rail and deck fittings.

DRAWING BOARDS.

Regular Meeting, November 15th, 1884.—Mr. Theodore Bergner, introduced by the Secretary, exhibited his designs for Drawing Boards. Its parallel ruler, which extends across the face of the board, is guided by means of an endless cord, stretched crosswise over four little grooved pulleys provided at the corners of the board. He

stated that extensive use for years has fully demonstrated its thorough reliability, even under the most adverse circumstances. The two portions of the crossed endless cord which run parallel with two opposite edges of the board, always move in the same direction; this equal direction and amount of movement is imparted to the blade, both ends of which are clamped to the cord. The parallelism thus obtained is not dependent upon the condition of the board. The ruler can be easily detached, and any required degree of inclination in either direction, given to it, by securing its two clamps to the cord at the relative points for the desired angular position of the ruling edge. End play of the ruler is admissible, and it may be moved by the hand at any point. This system is applied both to boards for table use and to upright boards, which latter are often preferred for hygienic and technical reasons.

A TRANSIT ROD.

Regular Meeting, November 15th, 1884.—Mr. Allen J. Fuller exhibited a new form of Transit Rod, which is made so that the point of the shoe is in the same plane as the face of the rod. There is an opening through the rod, from about 9 ins. above the point of the shoe to a height of 6 or 7 ft. At the top of this opening and on the face of the rod, is suspended a plumb-line, which hangs across a marked cross-piece near the lower end of the opening. The plumb-line indicates when the rod is plumb, after which it may be fastened to a hook on the under side of the cross-piece to prevent oscillation by the wind. The transitman sights to this line, which, with the dividing line on the face of the rod, forms a right line throughout its length, perpendicular to the point over which it is set. The rod is provided with short stay-chains, attached to pins, for driving in the ground, that will hold it when set over a tack centre or stone monument. It is also designed to be used instead of plumb-bobs in taking horizontal measurements with the tape-line, to save time and insure greater accuracy.

REMOVING AND REBUILDING A STAND PIPE.

Regular Meeting, November 15th, 1884.—Mr. W. Bugbee Smith described, with illustration, the method of removal of the West Philadelphia Stand Pipe, which was taken down in 1881, and the masonry and ornamental cast-iron work used in the construction of the Spring Garden Stand Pipe. The new pipe, which is of the same general design as the old, is 5 ft. in diam. and 156 ft. 6 ins. high, being 20 ft. higher than the old. The lower 53 ft. were of $\frac{3}{8}$-in. iron; the middle 50 ft. of $\frac{5}{16}$-in. iron, and the upper 53 ft. of $\frac{1}{4}$-in. iron. The longitudinal seams for the first 53 ft. were double riveted; all other seams single riveted. The bottom sheet was double riveted to a cast-iron flange. The weight of the pipe and flange was about 16 tons. The pipe was erected in one piece, by means of two poles, one on each side of the pipe, and was then lowered about 6 ft., and bolted to the top of the base casting. This operation took about 1 h. 40 m. The base casting is 5 ft. diam., 5 ft. 3 ins. high, and receives the 36-in. inlet pipe on one side. It is secured to the foundation masonry by four $2\frac{1}{2}$-inch bolts, which are keyed on the under side of large plates below the masonry. When the pipe had been secured, the ornamental masonry was built about it, to the height of 37 feet. To erect the ornamental iron work, which consists of columns in 10-ft. sections and a spiral stairway, a carriage supporting two sheaves was placed

upon the top of the pipe, where it turned freely. A rope ran up one side of the pipe, over the sheaves and down the other side, by means of which the columns, etc., were hoisted into position. The work was done upon a movable platform which surrounded the pipe, and rested on the rings which joined the tops of the columns. As each section of columns was secured in position, the platform was hoisted ready for the next section.

A 100-FOOT TURNTABLE,

Regular Meeting, December 20th, 1884.—Mr. John C. Trautwine, Jr., presented an illustrated description of a design for a 100-ft. turntable, by Mr. C. O. H. Fritzsche, of New York, for the N. Y., W. S. & B. R. R. Co., for use in their car shop. It was to carry a six-wheeled shifting engine, 30 ft. long, weighing 90,000 lbs., and two cars, each 36 ft. long, weighing 24,000 lbs. each: total extraneous load, 138,000 lbs.

The table is turned by a steam engine, which, with its boiler, is carried upon an iron platform, about 7½ x 13 ft., attached to one side of the turntable near the middle of its length, and thus revolving with it. The power of the engine is communicated, by means of bevel gearing and a long shaft running along the centre-line of the turntable, to a wheel in each end carriage.

ABSTRACT OF MINUTES OF MEETINGS.

Of the Club.

October 18th, 1884.—Regular meeting.—President William Ludlow in the chair; 25 members and 3 visitors present.

Mr. C. Henry Roney exhibited and described a Portable Storage Battery for Mining and Exploring Purposes.

Mr. Wm. L. Simpson exhibited and described the Thompson Indicator.

Mr. J. J. deKinder described the Repairs to the 36 in. Belmont Submerged Main, Philadelphia, recently made by him.

Mr. W. Bugbee Smith presented notes upon the Fire Protection of Mills.

The Secretary exhibited, for Mr. S. L. Smedley, a photo-lithographic reproduction of a topographical Map of Philadelphia, by John Hills, 1796, and pointed out some of the remarkable evidences of its great accuracy in detail.

Mr. Francis Lightfoot, of West Chester, introduced by the Secretary, explained a model of a Rail Joint in which no plates or loose pieces are required, the ends of the rail being lapped and bolted together through oblong slots.

November 1st, 1884.—Special Business Meeting.—President William Ludlow in the chair; 30 members present.

The Board of Directors reported their minutes since the last Business Meeting, and made special report that the occupancy of the new Club House had been delayed by the consideration of extensive changes in the block in which it is located, by the Trustees of the Girard Estate.

The Tellers of Election reported that 127 votes had been cast and the following gentlemen elected Active Members of the Club: Messrs. Bard Wells, Frank A. Hill, R. Meade Bache, Emil Forder, W. E. C. Coxe, Philip Pistor, O. B. Harden, Thos. H. Loomis, Barton Hoopes, Jr., Wm. F. Biddle, Lindley M. Winston, H. W. Sanborn, S. Craige McComb, Wm. H. McCallum and Wm. H. Wiley.

The Secretary presented, for Mr. A. W. Sheafer, Notes upon the Relative Cost of Haulage in the Anthracite Mines of Penna., by Mules and Locomotives.

The Secretary also exhibited for Mr. Sheafer, a set of Electrical Photographs of the Kohinoor Colliery Mine Workings.

The Secretary exhibited the Bush Interlocking Rail Bolts, which interlock within the tie under the middle of the rail. They are specially intended, it is believed, to resist the lateral strain of the train upon curves.

Mr. Thomas M. Cleemann continued some previous remarks that he had made on the Strength of Wrought Iron Columns, showing how some recent experiments by Mr. James Christie, at the Pencoyd Iron Works, gave values of the constants in Rankine's formula somewhat different from those generally used, and which would, therefore, be better to adopt for calculating their strength, in structures of American iron.

Mr. James Christie presented several statements with regard to these experiments.

The Secretary presented, for Mr. R. W. Jones, Notes upon the Blue Process, for the Reference Book.

Mr. C. A. Ashburner exhibited and described Part I of the large Atlas of the Anthracite Coal Fields of Pennsylvania, by the Second Geological Survey of Pennsylvania.

Capt. O. E. Michælis presented a blackboard description of

what he was *allowed to see* at the recent exhibition of the "Keeley Motor" in Philadelphia.

NOVEMBER 15TH, 1884.—Regular meeting.—Vice-President J. J. deKinder in the chair; 44 members and 2 visitors present.

Mr. John Haug presented a description, illustrated by drawings and test specimens, of Mr. William Astor's new Steam Yacht.

Mr. Fairman Rogers described his Steam Yacht "Magnolia."

The Secretary presented, for Mr. E. F. Smith, an illustrated description of a Floating Coffer Dam.

Mr. Theodore Bergner, introduced by the Secretary, exhibited and described his designs for Drawing Boards.

Mr. Robert P. Snowden presented an illustrated mathematical discussion of Formulæ for Frogs and Switches, with some notes as to putting in leads for the same.

The Secretary presented, for Mr. Graham Spencer, a description of the Kaolin Beds of Chester Co., Pa., and Newcastle Co., Del.

Mr. Allen J. Fuller exhibited a new form of Transit Rod.

The Secretary presented, for Mr. R. H. Soule, illustrated notes upon the West Shore Anthracite Engine, No. 24, designed by the late Howard Fry, Member of the Club, Supt. M. P. of that road.

The Secretary presented for Mr. A. H. Haig, a note upon the process of Copying Drawings in Blue Lines upon White Ground.

Mr. W. Bugbee Smith described, with illustration, the removal of the West Philadelphia Stand Pipe.

DECEMBER 6TH, 1884.—Business Meeting.—President William Ludlow in the chair; 32 members and 3 visitors present.

The Board of Directors reported their minutes, and that they had appointed, to conduct the Annual Election, Tellers, Messrs. J. E. Codman and T. M. Rogers, and Alternates, Messrs. Wm. McIlvaine and A. A. Stevenson.

Nominations were made for Officers for 1885, and other routine business transacted.

The Secretary presented a Memorial to Congress, which he had received from Mr. E. L. Corthell, C. E., asking that Civil Engineers be accorded the opportunity to attain equal standing with Military Engineers, in the Civil Engineering service of the

Government. It was referred to the members for individual signature.

An amendment (see minutes of January 10th, 1885) was offered to Secs. I and II, of Art. IV of the Constitution.

The Tellers of the Election of Members, Messrs. C. E. Billin and Lloyd Bankson, reported that the following gentlemen had been elected Active Members of the Club: Messrs. George Turner, Jr., George M. Newhall, Edw. Y. Townsend, Henry S. Drinker, F. W. Sargent, James Beatty, Jr., Richard Evans, Max B. Feldmann, C. Frederick Moore, John S. Elliott, Conway B. Hunt, John R. Hoffman, John Mullen, Robt. Wetherill, Ferdinand Philips and Theodore Bergner.

The Secretary read a communication from Mr. W. F. Wootten, announcing the death of Mr. Frederic C. Wootten, Member of the Club, and offered a Memorial Notice for publication in the Proceedings.

President Ludlow exhibited a specimen of Roe's Surveyor's Steel Tape and Reel, for which some improvements, over ordinary tapes, are claimed.

Mr. Edw. I. H. Howell presented a description of English Centrifugal Pumps.

Mr. A. A. Stevenson presented a series of Gas Engine Indicator Cards, which, being rather a novelty, are interesting, and seem to show good results.

Prof. L. M. Haupt read a paper, illustrated by model and photographs, on Movable Dams of the Chanoine-Pasqueau System.

A model, working upon continuous track, of appliances for Switching and Crossing Intersecting Lines on Cable Roads was exhibited, described and put in operation by Mr. Ramsden, son of the inventor. The operations of the grips, while apparently not complex, are hardly susceptible of a brief and clear written description.

Mr. H. W. Spangler presented, for Mr. P. A. Taylor, a sample and description of Wooden Water Pipe, laid by Stephen Girard in 1834, on Broad Mountain on the line of the Mahanoy and Shamokin Railroad, Schuylkill Co., Pa.

The Secretary exhibited, for Mr. C. A. Merriam, a series of interesting photographs of the track of the Mexican National Railway.

December 20th, 1884.—Regular meeting.—Past President Frederic Graff in the chair; 35 members and 3 visitors present.

Mr. Geo. S. Strong read a portion of the first of a series of papers upon the Future of Locomotive Building.

Gen. Russell Thayer read a paper upon the Navigation of the Air, with a Description of the Aërial Ship and the Theory and Practical Operation of its Motor.

Mr. Lloyd Bankson presented, for Mr. H. W. Spangler, an illustrated paper upon Measuring Chimney Draft.

The Secretary presented, for Mr. P. A. Taylor, an account of the enlargement of the East Mahanoy Tunnel, East Mahanoy Railroad, Schuylkill Co., Pa.

Mr. John C. Trautwine, Jr., presented an illustrated description of a design for a 100 ft. Turntable by Mr. C. O. H. Fritzsche, of New York, for the N. Y., W. S. & B. R. R.

January 10th, 1885.—Seventh Annual Meeting.—President William Ludlow in the chair; 56 members and 4 visitors present.

The Secretary and Treasurer presented his Annual Report. The expense for the year amounts to $3589.05; the receipts and other funds to $4413.81, leaving a balance of $824.76, or more than double the very satisfactory showing of last year. This is, of course, in addition to the value of the library and furniture.

The average attendance of members at meetings was over 54 per cent. greater than it was during the year 1883. The Active Membership of the Club has increased, during the year, from 244 to 363, or nearly 49 per cent.; 45½ per cent. of the members now reside without the city, and 23 per cent. without the State.

Club mail matter is now issued at the rate of about 15,000 letters and packages per annum.

On motion of the Secretary and Treasurer his accounts for 1884 were referred for audit to the Finance Committee of incoming Board of Directors.

President Ludlow delivered the Annual Address.

The deaths of our fellow-members, Arthur Robert Faunt Le Roy and William Lorenz, were announced.

The Tellers of Election, Messrs. J. E. Codman and T. M. Rogers, reported that the amendment to the Constitution creating the

class of Associate Members had received 136 affirmative and 12 negative votes, and was, therefore, carried.

The article, as amended, reads as follows:

ARTICLE IV. MEMBERS.

SECT. I.—*Civil, Mechanical and Mining Engineers, Geologists, Architects and other persons engaged in pursuits pertaining to Engineering, shall be eligible to membership.*

SECT. II.—*There shall be four classes of Members: Active, Corresponding, Honorary and Associate.*

Active Members shall be persons who are actively engaged in, or who have been in responsible charge of, engineering work, who will participate in promoting the interests of the Club, and who will, as often as may be, attend its meetings, present papers, and vote at elections.

* * * * * * * * * * * *

Associate Members shall be persons who are interested in the advancement of Engineering Science, and who will participate in promoting the interests of the Club.

They also reported that 153 votes had been polled for Officers for 1885, with the following result:

President, J. J. deKinder; Vice-President, Joseph N. DuBarry; Secretary and Treasurer, Howard Murphy; Directors, T. M. Cleemann, Frederic Graff, Rudolph Hering, William Ludlow and Henry G. Morris.

Mr. de Kinder assumed the chair with appropriate remarks. He specially urged increased social and professional activity in the Club, and the full contribution by each to the general store of information.

On motion of the Secretary, he was instructed to issue circulars to the members upon the subject of change of name of the Club with a view of obtaining their opinions. As a basis for expression the following names were proposed, but the suggestion of other names was to be invited: Engineers' Club of Philadelphia; Engineers' Society of Philadelphia; Engineers' Asssociation of Philadelphia; and Eastern Society of Engineers.

JANUARY 24TH, 1885.—Special Business Meeting.—President J. J. deKinder in the chair; 31 members present.

The resignations from Active Membership of Messrs. Walter Atlee, F. W. Dean, W. H. Heuer, A. B. Stovell and J. C. Turk, were read and accepted.

The Tellers of Election, Messrs. J. E. Codman and T. C. Smith, reported that the following gentlemen were elected Active Members of the Club: Messrs. Chas. M. Jarvis, Saml. J. Creswell, Joseph S. Ward, H. W. Dunne, Wm. M. Levering, Chas. P. McArthur, John B. Fontaine, Geo. G. Hood, John D. Newbold, T. A. Reilly, P. W. Taft and C. H. Middleton, Jr.

On motion of the Secretary, the President was authorized to appoint Tellers of Election of Members in advance of the meeting for election, and the said Tellers were authorized to receive and count, in advance, such portion of the letter ballots as may be received prior to the opening of the meeting.

Mr. John C. Trautwine, Jr., exhibited and described drawings of a large Land Dredge built by the Osgood Dredge Co., of Albany, New York, for the Pacific Guano Co.

Mr. Chas. T. Thompson presented a Description of the Construction and Manner of Turning of the Large Hoisting Drums of the Calumet and Hecla Mining Company.

Mr. Thompson also read an interesting letter from Mr. Henry A. Vezin, alluding to the Mining Methods in Colorado.

The Secretary was enabled to present, through the courtesy of Samuel C. Perkins, Esquire, who had loaned it for the purpose, a description of the so-called Artesian Wells of New York City, embodied in a written report thereupon by Dr. Cyrus Edson, Chief Inspector of the Health Department.

February 7th, 1885.—Regular Meeting.—Past President Frederic Graff in the chair; 46 members and 3 visitors present.

Mr. M. Van Harlingen presented a full description of the Phœnixville Tunnel on the Pennsylvania Schuylkill Valley Railroad, illustrated by drawings and photographs.

The Secretary presented, for Mr. A. Harvey Tyson, a paper upon the Sources of Pollution in Storage Reservoirs.

The subject was discussed by Mr. Chas. G. Darrach and Dr. H. M. Chance.

Mr. E. V. d'Invilliers mentioned an article, to which his atten-

tion had been called by Prof. L. M. Haupt, upon the Repairs to Chestnut Street Bridge, Philadelphia, in the *Railroad Gazette* of Jan. 30th, 1885. After some discussion, the further consideration of the subject was deferred, as a paper thereupon is anticipated.

The Secretary announced the death of our fellow-member, Mr. D. Hudson Shedaker, and asked that a committee be appointed to prepare a Memorial for the Proceedings. The chair appointed Messrs. James R. McClure, Joseph Johnson and John H. Dye, Chairman, and the meeting adjourned.

February 21st, 1885.—Regular meeting.—President J. J. de Kinder in the chair; 23 members and 2 visitors present.

The Secretary presented, for Mr. Henry A. Vezin, a set of Diagrams for Determining Belts and Pulleys and Shafts, with a description thereof. They were derived from Wieber's Skizzenbuch für den Ingenieur, but modified by Mr. Vezin to suit our units of weight and measure, and their application extended. They present the usual advantages of the graphic method; not only saving the time and mental exertion necessary to calculate by formula, but also presenting a picture of possible and desirable modifications of design.

He also presented similar Diagrams for Cast Iron Cogs.

Mr. J. Milton Titlow contributed a paper, illustrated by drawings and photographs, upon the Strengthening the West Main Abutment of Chestnut Street Bridge, Philadelphia.

The paper was discussed by Prof. L. M. Haupt and Mr. Howard Murphy.

March 7th, 1885.—Business meeting.—Past President Lewis M. Haupt in the chair; 50 members present. The Board of Directors submitted their minutes as their Report.

The Tellers of Election of Members, Messrs. John T. Boyd and J. E. Codman, reported that the following gentlemen had been elected Active Members of the Club: Messrs. A. W. Sims, Percy T. Osborne, A. H. Storrs, Wm. O. Dunbar, Morris P. Janney, John W. Henderson, Arthur H. Howland, P. D. Ford, and J. H. Nichol.

The resignations from Active Membership of Messrs. Lloyd Bankson and J. M. Rüdiger, Jr., were read and accepted.

The Secretary reported that he had issued the following circulars with regard to the proposition to change the name of the Club, the first having been sent with the notices of February 7th meeting.

As to Changing the Name of the Club.

This subject has been discussed by members for some time past. It is thought by many that our present name does not indicate the real character and scope of the organization. There is no disposition to do otherwise than increase our social features, but our real strength has always been and, it seems, always will be, in the line of professional discussion and publication. The names "*Engineers' Association of Philadelphia*" and "*Engineers' Society of Philadelphia*" have been suggested to meet the above conditions; and as, according to the last Annual Report, about 45½ per cent. of the members reside without the City of Philadelphia and 23 per cent. without the State of Pennsylvania, and as this class of non-resident members is rapidly increasing, the name "*Eastern Society of Engineers*" has been proposed.

Some members may prefer to retain the present name.

Please place your signature opposite the name you prefer, or any other name you have to suggest, and return the slip, in the directed envelope. It is important that a very general expression should be had upon this subject, so *every member* will please sign and return this slip.

Engineers' Club of Philadelphia . . . . . .
Engineers' Society of Philadelphia . . . . . .
Engineers' Association of Philadelphia . . . . . .
Eastern Society of Engineers . . . . . .
. . . . . .

(Second Circular.)

As to Changing the Name of the Club.

In response to the first circular, the following preferences have so far been expressed, and it is not likely that many more answers will be received. The names printed in Gothic type are those suggested in the first circular. The others are names suggested in response to the circular, and the figures show the written preferences expressed for each name.

Total Active Membership,	369
" number of expressions received,	206
Engineers' Club of Philadelphia,	70
Engineers' Society of Philadelphia,	22
Engineers' Association of Philadelphia,	13
Eastern Society of Engineers,	66
Eastern Association of Engineers,	1
Engineers' Club of Philadelphia, or Eastern Engineers' Club,	1

Engineers' Club of Philadelphia, or Philadelphia Society of Engineers,	1
Philadelphia Association of Engineers,	5
" Society " "	7
" " " " and Associates,	1
" " " Civil Engineers,	1
Engineers' Society of Eastern Pennsylvania,	4
Eastern Pennsylvania Engineers' Association,	1
Engineers' Society of Pennsylvania, or Engineers' Club of Philadelphia,	1
Pennsylvania Association of Engineers,	1
" Society of Civil Engineers,	1
" Society of Engineers,	3
Engineering Society of Pennsylvania,	1
Engineers' Club of Pennsylvania,	1
American Society of Engineers,	1
United States Engineering Association,	1
Society of American Engineers,	1
Engineers' Club of America,	1
Middle States Engineers' Society,	1
	136

Each member will analyze this vote according to his own judgment, but the following points are respectfully suggested:

1st.—That those who favor a change of name, including three who are doubtful, number	136
And those who do not,	70
	206
2d.—That of those who favor a change, there are, in favor of a name more geographically comprehensive,	84
Of a new local name,	49
And doubtful,	3
	136
3d.—That there are, in favor of "Eastern Society of Engineers,"	66
And in favor of all other new names,	70
	136
4th.—That there are, in favor of the word "Philadelphia,"	120
Against it,	84
And doubtful,	2
	206

It must be remembered, however, that many of the 70, in favor of "Engineers' Club of Philadelphia" (who are included in the above 120), are simply opposed to *changing the name* at all.

5th.—That there are in favor of the word "Society,"	109
Of the word "Club" (including the 70 in favor of present name),	73
Of the word "Association,"	22
And doubtful, ...	2
	206

And last, but not least, that, were this a vote upon a Constitutional Amendment to change the name, and were all in favor of change to unite upon one name, the vote would stand 136 to 70, or fall 4 votes short of the two-thirds majority necessary to pass the amendment.

What are we going to do about it?

February 28th, 1885.

HOWARD MURPHY,
Secretary and Treasurer.

Mr. William Wharton, Jr., read a comprehensive paper on the Construction of Street Railways in the United States, and exhibited in connection with the same, a number of varieties of street rails used in different cities on straight tracks and on curves.

He showed, by the working of a model, the system of transferring cars on the six tracks of the Brooklyn City Railroad Company, at their terminus near the east end of the New York and Brooklyn Bridge, designed by him some two years ago.

Mr. C. G. Darrach submitted his informal discussion of the Repairs to Chestnut Street Bridge, Philadelphia, which he had offered at a previous meeting, but which he had desired to be withheld from the minutes until Mr. Titlow's paper was presented.

After considerable discussion it was finally moved that it be the sense of this meeting that it is not now advisable to change the name of the club, and the motion was carried by a vote of 18 to 16.

The Secretary presented, for Capt. P. C. F. West, a paper upon Isthmian Transits.

Mr. Geo. S. Strong presented some notes upon recent Locomotive Construction, showing blackboard sketches of indicator cards.

Messrs. James R. McClure, Joseph Johnson and John H. Dye, Chairman, the Committee on Memorial of Mr. D. Hudson Shedaker, our late fellow-member, presented a sketch of his life and professional labors.

March 31st, 1885.—Regular meeting.—President J. J. de Kinder in the chair; 32 members and 7 visitors present.

Mr. E. S. Hutchinson presented notes upon the Latitude and Departure Method of Calculating Areas.

Mr. John Wood, Jr., visitor, exhibited handsome working models of cars and tracks equipped with the Curtis & Wood Automatic Car Coupler, and fully explained its workings.

The Secretary presented, by title, for Prof. L. M. Haupt, a revision of his paper upon Scales of Maps, which Prof. Haupt has prepared for the Club Reference Book.

The discussion on strengthening the West Main Abutment of Chestnut Street Bridge was continued by the author of the paper, Mr. J. Milton Titlow, and Prof. L. M. Haupt, Messrs. Rudolph Hering and Howard Murphy.

April 4th, 1885.—Regular meeting.—President J. J. deKinder in the chair; 46 members and 4 visitors present.

The Secretary presented, for Mr. Jacob H. Yocum, an illustrated description of the recently constructed Water Works at Columbus, Ga.

The discussion of Strengthening the West Main Abutment of the Chestnut Street Bridge was continued by Messrs. C. G. Darrach, Rudolph Hering, Prof. L. M. Haupt and others.

The Secretary announced the death of the venerable Col. James Worrall, member of the Club.

April 18th, 1885.—Special Business Meeting.—Past President Rudolph Hering in the chair; 34 members and 4 visitors present.

The following resolution, offered by Prof. L. M. Haupt, was unanimously adopted: That a Committee be appointed to draft a Memorial to the Legislature in behalf of the proposed topographical survey of this State, and to report at the next meeting. The chair subsequently appointed, as this Committee, Prof. L. M. Haupt, Chairman, Messrs. C. E. Billin, T. M. Cleemann, Frederic Graff and President J. J. deKinder.

The following Committee was appointed to prepare a Memorial for publication in our Proceedings of the late Col. James Worrall, Member of the Club: Messrs. J. Simpson Africa, Chairman, L. M. Haupt and A. E. Lehman.

A handsome framed engraving of the old Wernwag Bridge was presented to the Club, accompanied by a descriptive letter, by Mr. Percy T. Osborne, on behalf of his father, Mr. Richard B. Osborne, Civil Engineer.

Mr. James F. Wood described the Sewerage Work now in progress at Atlantic City, N. J.

Mr. Jones Wister presented a description of the Beaumont Rock Drill, which is said to bore a 7 ft. 2 in. hole at the rate of from 42 to 120 ft. per week; to be suited to all rocks, but the very hardest, and to avoid the leakage and foul air incident to the use of dynamite. The workings of the drill were discussed by several members. Mr. John Fernie, M. Inst. C. E., who was present as the guest of the Club, at the request of the Secretary, described the character of the rock formation in which this drill had been used.

The Secretary presented a specimen of the work done by the Air Brush, which works upon the general principle of the atomizer, and by which shade effects on drawings are rapidly and permanently effected.

The balance of the evening was occupied in the continuation of the discussion of the condition of Chestnut St. Bridge, Philadelphia. It was opened by Dr. H. M. Chance, who gave the result of his examinations of the displacement of the railing, and was participated in by a number of members, but it appeared that no change of previously expressed opinions had taken place.

Of the Board of Directors.

October 4th, 1884.—Special Meeting.—Vice-President J. J. deKinder in the chair.

The Secretary read a communication to the Club from the Board of Managers of the Association of Engineering Societies, and was directed by unanimous vote of the Board to reply that the Board adhere to their recently expressed opinion that there should be no change in our present policy as to our publications. The matter was then referred to the Business Meeting of the Club.

The Secretary recommended that he be authorized to print papers in the Proceedings, with the approval of the Committee on Publication, prior to their formal presentation to the meeting of the Club, when, during the summer adjournment, or at any other time, the issue of Proceedings would be facilitated thereby. It was so ordered.

The payment of bills to the amount of $942.65, which had been endorsed by the Finance Committee, was approved.

October 23d, 1884.—Special Meeting.—Mr. Henry G. Morris in the chair.

A discussion of the matter of seeking another Club House than the one proposed, owing to the uncertainty of the movement of the Trustees of the Girard Estate in the matter, was closed by referring the matter to the Committee on New Club House.

November 15th, 1884.—Vice-President deKinder in the chair. The Secretary was instructed to advertise for a suitable house for the Club.

December 6th, 1884.—Special Meeting.—President Ludlow in the chair.

The following were appointed Tellers to conduct the Annual Election of Officers: Tellers, Messrs. J. E. Codman and T. M. Rogers; Alternates, Messrs. Wm. McIlvaine and A. A. Stevenson.

January 24th, 1885.—President deKinder in the chair. The following Standing Committees for 1885, were appointed by the President:

Finance.—Messrs. Graff and Morris.
Membership.—Messrs. Du Barry and Morris.
Publication.— " Cleemann and Ludlow.
Library.— " Hering and Cleemann.

The Secretary suggested that President deKinder be requested to sit for his phototype portrait, to be inserted in the Proceedings. Adopted.

The Committee on New House, Messrs. Graff, Morris and Col. Ludlow, Chairman, was continued.

February 21st, 1885.—Regular Meeting.—President deKinder in the chair. Routine business only.

March 21st, 1885.—Regular Meeting.—President J. J. de Kinder in the chair.

The Secretary submitted the following form of application for Associate Membership and the same was approved.

ENGINEERS' CLUB OF PHILADELPHIA.

Mr. . . . . . .

Occupation, ...

Address, ...

. . . . . .

being interested in the advancement of Engineering Science, and being desirous of participating in promoting the interests of the Club, we hereby respectfully propose him for admission to the Club as *Associate Member.*

We are personally acquainted with candidate, believe him to be, in all respects, a proper person to be admitted, and are assured that he will become a member if elected.

. . . . . .

. . . . . .

TO THE BOARD OF DIRECTORS,

GENTLEMEN.—Having considered the foregoing application, we hereby report that the candidate is eligible under the Constitution and By-Laws.

Respectfully,

Committee on Membership. { . . . . . / . . . . . / . . . . . }

The Secretary suggested that Active Members desiring to become Associate Members may do so upon written application, if the same is approved by the Board. On motion of Mr. Du Barry the question was referred to a committee of three. The President subsequently appointed Messrs. Du Barry, Chairman, Cleemann and Hering as the committee.

The Secretary stated that it is probable that a house on Girard Street will be vacated by May 1st, and requested the Board to authorize him to make official application therefor, with the understanding that it be placed in the same condition as was proposed in the case of 1113 Girard Street. Mr. Du Barry considered that the Committee on New Club House should be heard from upon the subject, whereupon Messrs. Graff and Morris, a majority

of the committee, who were present, recommended the adoption of the Secretary's suggestion and the Board ordered it to be carried out.

The Secretary suggested that, as the author of a particular paper is not responsible for the general make-up and consequent cost of the number of Proceedings in which it appears, the uniform price of ten cents each be fixed for author's extra copies. It was so ordered.

The Secretary suggested that back forms of the Reference Book be furnished free of cost to new members who apply for them. It was so ordered.

The Secretary announced that the last edition of the Constitution and By-Laws is almost exhausted, and asked for instructions as to printing a new edition, in view of no report having been received from the committee appointed by the Club to revise the By-Laws. He was instructed to notify this committee as to the situation.

President deKinder announced his intention of translating a number of Municipal Reports of European cities, containing much valuable data as to municipal engineering, and asked whether such matter would be of value for Club publication.

The Board were of unanimous opinion that it would form a valuable Club document and recommended its publication as a separate volume when it should be completed by Mr. deKinder.

April 4th, 1885.—Special Meeting.—President deKinder in the chair.

President deKinder announced that he had made inquiries as to the matter of the Girard Street house for the Club, and had learned that the desired improvements would be made and made promptly.

Messrs. T. M. Cleemann, R. Hering and J. N. Du Barry, Chairman, the committee to whom was referred the question of transfer of members now on Active list to Associate list, reported in favor of making such changes under the following rules:

1. Application shall be made for such exchange to the Secretary of the Club.

2. The Secretary shall present such application to the Board

of Directors at the next meeting after its receipt, when a vote on such transfer shall be taken, and if approved by a majority vote, the Secretary shall have authority to make such change on the list of membership and advise the applicant thereof.

3. The dues for Associate Members shall be the same as those of Active Members.

The Secretary presented a communication from Mr. John W. Townsend requesting that he and his father, Mr. E. Y. Townsend, be transferred to the associate list. The applications were approved by the Board.

The Secretary recommended that the back numbers of Proceedings now on hand be arranged, first in complete sets to date, and, second, that such numbers as then remained be arranged in complete volumes, and that these sets and volumes be not broken hereafter. It was so ordered.

April 18th, 1885.—Regular meeting.—Past President Rudolph Hering in the chair. Routine business only.

CONTRIBUTIONS TO THE LIBRARY.

From November 18th, 1884, to May 1st, 1885.

From the INSTITUTION OF CIVIL ENGINEERS, London.

Sennett—The Electric Light.
Rich—Pumping Engines.
Mais—Independent Engine Tests.
Cowper—The Steam Engine.
Wyatt—Paper Making.
Jamieson—Electric Lighting for Steamships.
Cunningham—Removal of Buddonness Lighthouse.
Kraft—Compressed Air Machinery.
Reynolds-General Theory of Thermo-Dynamics.
Roberts—The Barmouth Waterworks.
Brady—Burnham Sewage Outfall Works.
Jackson—Hauling Out and Launching Vessels Sideways.
Guppy—Pumping Machinery.
Abstract of Papers in Foreign Transactions and Periodicals—Vols. LXXVIII and LXXIX.

From the NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, Newcastle-Upon-Tyne.

Transactions—Vol. XXXIII, Part VI.
" —Vol. XXXIV, Parts I and II.
The Strata of Northumberland and Durham as Proved by Sinkings and Borings. 1885.

From the LIVERPOOL ENGINEERING SOCIETY.

Annual Report. 1884.
Transactions. Vol. I, 1881, to Vol. V, 1885, both inclusive.

From the AËRONAUTICAL SOCIETY OF GREAT BRITAIN, London.

Brearey—The Relations of the Aëronautical Society of Great Britain with Respect to Aëronautics. 2 copies.

From the SOCIETY OF CIVIL ENGINEERS, Paris.

Mémoires—Aug., Sept., Oct., Nov. and Dec., 1884; Jan., 1885.

Séance du 9 Janvier, 1885.

Annuaire de 1885.

From L'ADMINISTRATION DES PONTS ET CHAUSSÉES, Paris.

Annales—Sept., Oct., Nov., Dec., 1884; Jan., Feb., March, 1885.

From the AUSTRIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Vienna.

Wochenschrift.

Zeitschrift—Part VI, 1884.

From the VEREIN FÜR BAUKUNDE, Stuttgart, Germany.

Proceedings—Part II, 1884.

From the NORWEGIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Kristiania.

Norsk Teknisk Tidsskrift—II, 5 and 6, 1884; III, 1-2, 1885.

From the SWEDISH SOCIETY OF CIVIL ENGINEERS, Stockholm.

Proceedings — Fjerde Häftet, Femte Häftet, Sjette Häftet, 1884.

From the PORTUGUESE SOCIETY OF CIVIL ENGINEERS, Lisbon.

Proceedings—Sept.-Oct. and Nov.-Dec., 1884; Jan.-Feb., 1885.

From the ARGENTINE SCIENTIFIC SOCIETY, Buenos Aires.

Anales—Oct., Nov. and Dec., 1884; Jan., Feb., 1885.

Holmberg—La Sierra de Curá-Malal.

From the MANITOBA HISTORICAL AND SCIENTIFIC SOCIETY, Winnepeg.

Transactions—1884-5. 5 pamphlets.

From the ASSOCIATION OF DOMINION LAND SURVEYORS, Ottawa, Canada.

Proceedings of Meeting—Feb., 1883.
" of First Annual Meeting—Feb., 1884.
" of Second " " " 1885.

From the AMERICAN SOCIETY OF CIVIL ENGINEERS, New York.

Transactions—Oct., Nov., Dec., 1884; Jan., 1885.

From the AMERICAN INSTITUTE OF MINING ENGINEERS, New York.

Transactions—Vol. XII, June, 1883, to Feb., 1884.
" Advance Sheets.

From the AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York.

Officers, Members and Rules—Jan. 1st, 1885.

From the MASTER CAR BUILDERS' ASSOCIATION.

Proceedings of 18th Annual Convention, Saratoga, July, 1884.

From the UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS, Phila.

Journal—Dec., 1884; Feb., 1885.

Index to Vol. V.

From the AMERICAN SHIPMASTERS' ASSOCIATION, New York.

Record of American and Foreign Shipping, 1885 Bound.

Supplements—1, 2, 3, 4, 5, 6 and 7.

From the INTERNATIONAL INSTITUTE FOR PRESERVING AND PERFECTING WEIGHTS AND MEASURES.

The International Standard—Nov., 1884; Jan. and March, 1885.

From the ASSOCIATION OF ENGINEERING SOCIETIES, New York.

Journal—Nov., Dec., 1884; Jan., Feb., March, April, 1885.

From the BOSTON SOCIETY OF CIVIL ENGINEERS.

Constitution and By-Laws and List of Members, Feb., 1885.

From the RENSSELAER SOCIETY OF ENGINEERS, Troy, New York.

Selected Papers—Vol. I, No. 2, March, 1885.

From the WESTERN SOCIETY OF ENGINEERS, Chicago, Ill.

Proceedings.

From the ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA, Pittsburgh.

Transactions—Advance Sheets.

From the AMERICAN PHILOSOPHICAL SOCIETY, Philadelphia.

Proceedings—Vol. XXI, No. 116, 1884, and Vol. XXII, Part I, No. 117, 1885.

Register of Papers Published in Transactions and Proceedings.

From the PHILADELPHIA SOCIAL SCIENCE ASSOCIATION.

Morris—The Milk Supply of Our Large Cities 1884.

Anders—Sanitary Influences of Forest Growth 1885.

14th Annual Report for 1884.

From the FRANKLIN INSTITUTE, Phila.

Journal—Dec., 1884; Jan., Feb., March, April, May, 1885.

Subject Catalogue of Memorial Library of International Electrical Exhibition, 1884.

Electrical Exhibition—Reports of Examiners Secs. XIV-XVI, XVIII, XIX, XXI, XXIV XXVII and XXX.

From the BOSTON PUBLIC LIBRARY.

Bulletin—Winter Number, 1885.

From MESSRS. BASSETT & NUTE, Civil Engineers, Newark, N. J,

Report on Sewerage and Sewage Disposal of East Orange, N. J , 1885.

From the LIBRARY CO. OF PHILA.

Bulletin—Jan., 1885.

From the GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

Tolmie & Dawson—Comparative Vocabularies of the Indian Tribes of British Columbia. 1884.

Selwyn & Dawson—Descriptive Sketch of the Physical Geography and Geology of the Dominion of Canada. 1884. Maps.

From the ENGINEER DEPARTMENT, U.S.A., Washington, D. C.

Annual Report of Chief of Engineers, 1884, in 4 parts. Bound.

From the U. S. COAST AND GEODETIC SURVEY, Washington, D. C.

Report—1883. Bound.

From the U. S. COAST AND GEODETIC SURVEY, Philadelphia Office.

Physical Survey, Delaware River,	App.	9, 1878
Addendum to the same,	"	13, 1879
Comparison of the same,	"	9, 1880
Estuary of the Delaware,	"	8, 1883
Meteorological Records,	"	10, 1878
Report on Geodetic Night Signals,	"	8, 1880
Rep. on Blue Clay, Mississippi River,	"	12, 1880
A Treatise on the Plane Table,	"	13, 1880
General Index of Scientific Papers,	"	6, 1881
Field Work of Triangulation,	"	9, 1882
Descriptive Cat. of Publications,	"	6, 1883
Construction of Tripods and Scaffolds,	"	10, 1882
Table of Depths of Harbors, Coast of U.S.,	"	7, 1883
Catalogue of Charts,		1883.

From the U. S. GEOLOGICAL SURVEY, Washington, D. C.

3d Annual Report, 1881-82. Bound.

Geology of the Comstock Lode and the Washoe District—Text and Atlas, 1882. Bound.

Bulletins—No. 2, 1883, and 3, 4, 5 and 6, 1884.

From the U. S. NAVY DEPARTMENT, Washington, D. C.

Report of the Gun Foundry Board, with Supplement. 1884. Bound.

Harber—Search for the Missing People of the Jeannette Expedition, etc. 1884.

The Maritime Canal of Suez from 1869 to 1884.

Oration of Hon. Thomas F. Bayard at Unveiling of Du Pont Statue—Dec., 1884.

From the DEPARTMENT OF INTERNAL AFFAIRS, PENNA., Harrisburg.

Secretary's Annual Report, 1884—Land Office and Assessments.

From the SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA, Phila.

Report of Commissioners to Legislature, Jan. 1st, 1885.

Grand Atlas, Div. 1, Part I.

Maps and Charts, RR.

Report, K 4.

From the SCHOOL OF MINES, COLUMBIA COLLEGE, New York.

Quarterly—Nov., 1884; Jan., 1885.

From MESSRS. A. P. TURNER & CO., London.

Financial Letters, Jan. 10th, Feb. 14th, March 14th, 1885.

From the PENNSYLVANIA R. R. CO., Phila.

Transportation Lines Owned, Leased and Controlled by P. R. R., Jan. 1st, 1885.

From MR. JOHN KENNEDY, Chief Engineer of Harbors, Montreal, Canada.

Annual Reps. of Harbor Commissioners for 1884.

From the SPICKET RIVER VALLEY COMMISSIONERS, Lawrence, Mass.

3d, 4th and 5th Quarterly Reports, 1884.

From MR. GEO. E. EVANS, City Engineer, Lowell, Mass.

12th Annual Report Lowell Water Board. 1885.

From MR. SAMUEL M. GRAY, City Engineer, Providence, R. I.

Proposed Plan for a Sewerage System. 1884.

From MR. JOHN COLLETT, State Geologist, Indianapolis, Ind.

Reports—1883 and 1884. Bound.

From HON. W. R. VAUGHAN, Mayor of Council Bluffs, Iowa.

Third Message—March, 1885.

From MR. W. B. KNIGHT, City Engineer, Kansas City, Mo.

Report for 1884.

From MR. RICHARD B. OSBORNE, Civil Engineer, Phila.

Wernwag Bridge, Phila.—Framed Print.

From MESSRS. ROBERT GLENDENNING & CO., Phila.

The Manual of Statistics—1885.

From the Author, MR. C. A. ASHBURNER Member of the Club.

Sketch of Geology of Carbon Co., Pa.—1884.

From the Author, DR. H. M. CHANCE, Member of the Club.

The Relative Value of Coals to the Consumer—1885.

From MAJ. H. W. CLARKE, Member of the Club.

Supervisor's Manual, Onondaga Co., N Y., 1884–5.

Proceedings of Board of City Auditors, Syracuse, N. Y., 1885.

From MR. THOMAS C. CLARKE, Member of the Club.

Van Nostrand's Engineering Magazine—1869 (Vol. I) to 1878, both inclusive, bound, and 1879 to 1884, both inclusive, in paper.

From MR. CHAS. H. HASWELL, Member of the Club.

Lundborg—Improvements in Naval Architecture, Trans. American Yacht Club, 1885.

From the Author, MR. E. S. HUTCHINSON, Member of the Club.

Notes on Coal Dust in Colliery Explosions.

From MR. CHAS. M. JARVIS, Member of the Club.

Six Large Bridge Photographs. Framed.

From MR. R. H. SOULE, Member of the Club.

Anthracite Locomotive No. 24, N. Y., W. S. & B. R. R.—Framed Photograph.

From MR. P. A. TAYLOR, Member of the Club.

Specimen Wooden Water Pipe, Laid by Stephen Girard, in 1834, in Mahanoy Valley, Pa.

Chillson—Report of Rain and Snow Fall in Palo Alto, Schuylkill Co., Pa., during 1884.

From MR. JOHN C. TRAUTWINE, JR., Member of the Club.

Trautwine's Engineers' Pocket Book—New Revised and Enlarged Edition. 1885. Bound.

ADDITIONS TO EXCHANGE LIST:

Liverpool Engineering Society, England.

Association of Dominion Land Surveyors, Prestou, Ontario.

Department of Internal Affairs of Pennsylvania, Harrisburg.

CHANGES IN LIST OF MEMBERS.

Active.

Additions, January 24th, 1885.

Jarvis, Chas. M., Vice Pres. and Chief Engr. Berlin Iron Bridge Co., East Berlin, Conn.

Creswell, Saml. J., Iron Founder, 23d and Cherry St., Phila.

Ward, Jos. S., Asst. Supervisor P. & R. R. R., 9th and Columbia Ave., Phila.

Dunne, H. W., Supt. N. Y., Phila. & Norfolk R. R., Cape Charles, Va.

Levering, Wm. M., P. A. Engr. Wilson Bros. & Co., 435 Chestnut St., Phila.

McArthur, Chas. P., Asst. Engr. P. R. R., Altoona, Pa.

Fontaine, John B., Mech. Engr. Eagle Iron Works, 1646 Franklin St., Phila.

Hood, Geo. G., Asst. Engr. P. & R. R. R., Mt. Airy, Phila.

Newbold, John D., Mech. Engr. and Mfr., Eagle Works, Norristown, Pa.

Reilly, T. A., Engineer and Contractor,
Pottsville, Pa.
Taft, P. W., Mech Engr. Vulcan Steel Works,
234 N. Front St., Phila.
Middleton, Jr., C. H., Civil Engr.,
Greensburg, Westmoreland Co., Pa.

Additions, March, 7th, 1885.

Sims, A. W., Engr. and Supt. E. Broad Top R. R. and Furnaces,
Orbisonia, Huntingdon Co., Pa.
Osborne, Percy T., Civil Engineer,
302 Walnut St., Phila.
Storrs, A. H., Supt. J. Langdon & Co. Collieries,
Shamokin, Pa.
Dunbar, Wm. O., Mech. Engr. Signal Depot P. R. R.,
233 S. 4th St., Phila.
Janney, Morris P., Mech. and Blast Furnace Engr.,
Pottstown, Montgomery Co., Pa.
Henderson, John W., Mech. Engr. Wharton Switch Co.,
1306 Arch St., Phila.
Howland, Arthur H., Civil Engineer,
U. S. Hotel, Boston, Mass.
Ford, P. D., Supervisor Div. C., N. Y. Div. P. R. R.,
Tacony, Phila.
Nichol, J. H., Supervisor W. J. R. R.,
Millville, N. J.,

Additions, May 2d, 1885.

Hirsh, Harry B.,
1318 Marshall St., Phila.
Price, Geo. B., Mech. Engr. Baldwin Locomotive Works,
128 N. 12th St., Phila.
Schutte, Louis, Mech. Engr. and Machinist,
12th & Thompson Sts., Phila.
Livingston, Max, Supt. Atlantic Refining Co.,
307 Walnut St., Phila.
Gill, John L.,
32 N. 5th St., Phila.
Dodge, W. F., L. &. W. Coal Co.,
Wilkes-Barre, Pa.

Mitchell, S. P., Res. Engr. Phila. Branch B. & O. R. R.,
North East, Md.

Burr, Wm. H., Phœnix Bridge Co.,
Phœnixville, Pa.

Thompson, Heber S., Civil and Mining Engr. Girard Estate,
Room 14, Morris Building, Pottsville, Schuylkill Co., Pa.

Hoyt, Wm. J., Engineer and Machinist,
Columbia, Pa.

Taylor, Frank H., Sec. and Treas. Manly & Cooper Mfg. Co.,
42d and Elm Ave., Phila.

Additions, June 20th, 1885.

Longstreth, Edward., Mech. Engr. Baldwin Locomotive Works,
500 N. Broad St., Phila.

Sundstrom, C. A., Asst. Engr. P. R. R.,
Sumac St., Wissahickon, Phila.

Sims, H. N., Civ. and Min. Engr.,
Orbisonia, Huntingdon Co., Pa.

Garrison, F. L., Min. and Metallurgical Engr.,
Radnor, Del. Co., Pa.

Felton, Herbert. C., Sec. and Treas. and Supt. Kaighn's Pt. and
Phila. Ferry Co., Camden, N. J.

Hewitt, Geo. W., Architect,
310 Chestnut St., Phila.

Martin, W. K., Asst. Engr. P. W. & B. R. R.,
Wilmington, Del.

Mitchell, A. G., Asst. Supervisor P. R. R.,
Spruce Creek, Huntingdon Co., Pa.

Forsythe, Wm. T., Asst. Engr. Phila. Water Dept.,
Box 838, Phila. P. O.

Taylor, Chas. E., Asst. Engr. Phila. Water Dept.,
816 N. 21st St., Phila.

Cheyney, Geo. S., Jr., Asst. Engr. Phila. Water Dept.,
Cheyney, Delaware Co., Pa.

Johnston, Edward H., Supt. Wharton Switch Co.,
3720 Hamilton St., Phila.

Wyeth, Charles, Civil Engr.,
New Dorp, Staten Id., N. Y.

Baizley, Rudolph, Mech. Engr.,
522 S. Delaware Ave., Phila.

Corthell, E. L., Chief Engr. Tehuantepec Ship Ry.,
Room 709, 34 Nassau St., N. Y.

Resignations.

Atlee, Walter,
Dean, F. W.,
Heuer, W. H.,
Stovell, A. B.,
Turk, J. C.,
Bankson, Lloyd,
Rüdiger, Jr., J. M.

Deceased.

Wootten, Frederic Copeland, November 16th, 1884.
Faunt Le Roy, Arthur Robert, December 26th, 1884.
Lorenz, William, December 29th, 1884.
Shedaker, David Hudson, February, 5th, 1885.
Worrall, James, April, 1st, 1885.

ASSOCIATE.

Transferred from Active List.

Townsend, Edw. Y.,
Townsend, John W.

Additions, June 20th, 1885.

Moorhead, Wm. S., Mfr. Terra Cotta Pipe, etc.,
11 S. 7th St., Phila.
Strawbridge, W. C., Patent Law, and Patent Soliciting,
903 Walnut St., Phila.
Taylor, J. Bonsall, Patent Law, and Patent Soliciting,
903 Walnut St., Phila.
Schwacke, Justus H., Agt. Wm. Sellers & Co.,
1600 Hamilton St., Phila.

Statement of Membership to June 20th, inclusive, 1885.

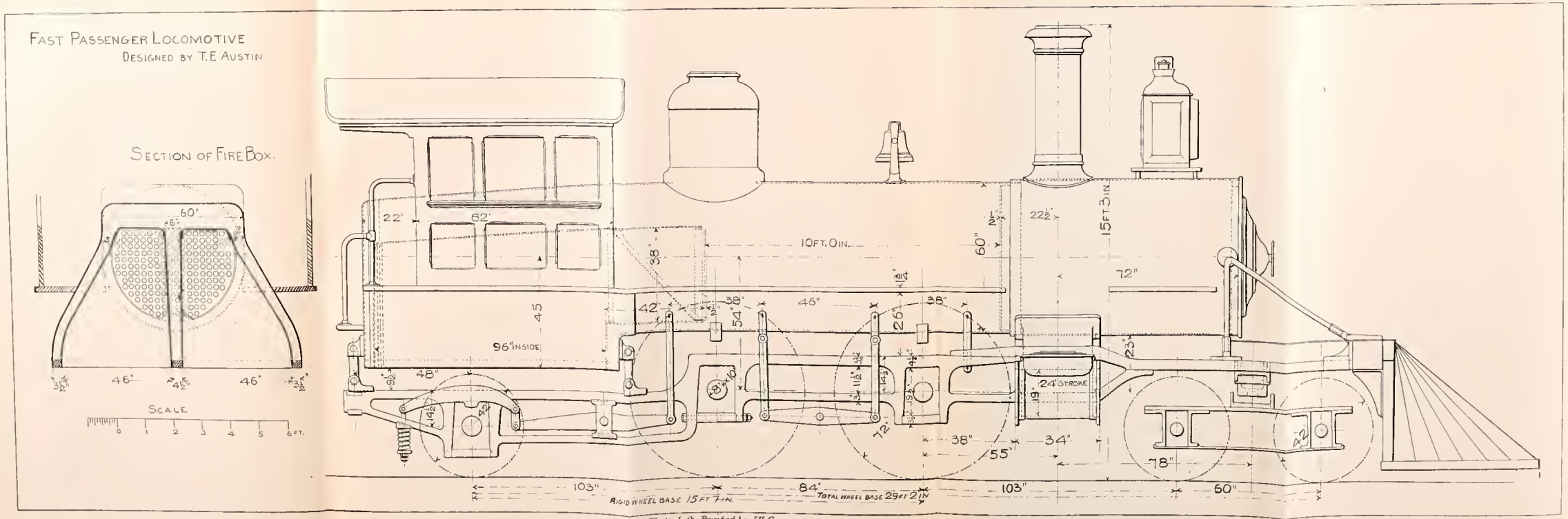
Honorary, 3; Corresponding, 5; Active, 399; Associate, 6.

BOOK NOTICES.

THE CIVIL ENGINEERS' POCKET BOOK, by John C. Trautwine, C. E. Twenty-second thousand, revised, corrected and enlarged by John C. Trautwine, Jr., C. E. New York, John Wiley & Sons, 1885.

The long expected, revised edition of Trautwine's Pocket Book has at last appeared, and we give it a hearty welcome. A book that has proved its value to the profession by a public demand for 22,000 copies, seems above criticism on the part of one of the perhaps less than that number of civil engineers in the country, and we are not presumptuous enough to attempt it. We therefore only call the attention of our brethren to some facts that increase the value of this edition over its predecessors. In the first place many mechanical improvements have been introduced. Matter bearing on a subject, where separated before, has now been brought together in the same part of the book, and the arrangement revised into a rational system. Several new tables have been added, whose standard of accuracy has been as jealously guarded and steadily maintained as those of previous editions. Much information in regard to water pipe, wire ropes and prices of materials have been added. More complete tables of the strength of American timber and American iron, and American types of boiler plate bridges are given. The portion in stresses in trusses does not seem to be altogether in place in the book. The method of treating them too seems cumbrous, and we think some special manuals on bridge construction are to be preferred. The contractor will find valuable information on rock drills and explosives, as well as the modern methods of earth excavations by drag scrapers and steam excavators. We especially call the attention of members of the Club to the ingenious formula on page 254, for the discharge through a compound pipe, since it has been devised by our Secretary. It is, we believe, the only one that has ever been proposed for such a case. In conclusion, we are glad to state that the want of earlier editions of a complete index has now been very satisfactorily overcome, thirty-four pages being occupied with this most essential feature of such a book.

C———.



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42"

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

Vol. V.] AUGUST, 1885. [No. 2.

VIII.

FAST PASSENGER LOCOMOTIVES.

By T. EVERETT AUSTIN, Member of the Club.

Read May 2d, 1885.

THE proper design for a locomotive that should be capable of developing a high speed (of say 60 miles an hour) under ordinary conditions of travel, and that should be both economical and powerful in practice, is a problem that has engaged the attention of engineers and master mechanics of railroads from the time of the "Old Ironsides" until the present day. Some of the more recent efforts in this direction have been the Fontain Locomotive of glorious memory and the "Baldwin Bicycle." Turning to those that are to-day doing good service, we might mention first, what the *American Machinist*, of January 7th, 1882, calls the swiftest American locomotive, and from which issue the following description is taken:

"With the rapidly increasing passenger traffic upon the railroads in this country has also come the necessity of increased speed, and to-day all the railroad companies controlling trunk lines are striving with each other to see which can make the best time with express trains."

"The Master Mechanics' Association have a standing com-

mittee appointed to determine which is the best form of fast passenger locomotive. The locomotive builders are also exercising their brains actively in endeavoring to produce a locomotive that shall combine power, speed and economy, three essential requisites in accomplishing the service desired. * * * A locomotive lately built by the Baldwin Locomotive Works of Philadelphia, for the Central Railroad of New Jersey. * * * This locomotive is considered by its builders to be their best design. * * * Four locomotives * * two with 18 in. × 24 in. cylinders, and two with 19 in. ×24 in. cylinders are now running. * * In general appearance it * * resembles the usual style of first-class eight-wheel locomotives, but with some very important improvements. In order to supply steam to larger cylinders, a larger furnace, more heating surface and greater boiler capacity are required. In the ordinary passenger locomotive the boiler sets inside the frames, and the necessary water spaces at either side of the fire-box greatly reduces the width of it. These water spaces are made as small as is considered safe, in order to get the necessary grate surface; to overcome one evil another is introduced, since the introduction of anthracite coal as a fuel upon locomotives, a larger heating surface is required; at first only the best quality was used, but lately coal dust has been successfully burned to some extent. * * * Boilers have recently been placed upon the top of the frames which admits of their being made as wide or wider, if necessary, than the outside of the frames. This improvement admits of a wider fire-box and larger water spaces, but the boiler sets higher, and the depth of the fire-box is very much reduced."

The following are some of the principal dimensions: Gauge of road, 4 ft. 8½ in. Boiler material, Otis steel, ⅜ in. thick. Shell 52 in. diameter. Style, wagon top. Fire door, 16 in. diameter. Dome, 32 in. diameter. Fire-box, 125⅞ in. long × 43¾ in. wide, corrugated sides. Depth, front, 51¾ in., back 42½ in. Crown sheet, ⅜ in. thick. Tube sheet, ½ in. thick. Sides ¼ in., and back $\frac{5}{16}$ in. thick. Water spaces, front, 4 in. Sides and back 3 in. Crown bars 5 in. × ¾ in., placed 1½ in. above crown. Crown bar bolts ⅞ in., screwed through sheets with nut below. Combustion chamber 5 in. long. 200 tubes 2 in. diameter × 11 ft. 5⅞ in. long, No. 12,

wrought iron ends, arranged for copper rings. F. B. end, wrought iron dry pipe, 8 in. diameter. Grate water tubes $2\frac{1}{4}$ in. diameter. Drain grate area, 38 sq. ft. Heating surface in fire-box 145 sq. ft. In tubes 1,175 sq. ft. Total, 1,320 sq. ft. Steam pressure 140 lbs. per sq. in. Rigid wheel base 7 ft. 6 in. Total wheel base 21 ft. 8 in. Weight in working order 93,000 lbs. Cylinders 18 in. diameter × 24 in. stroke. Driving wheels 68 in. diameter. Driving axle, Otis steel journals, $7\frac{1}{2}$ in. diameter × $8\frac{1}{2}$ in. long. Smoke stack, straight, $16\frac{3}{4}$ in. diameter × 14 ft. 10 in. height above rail. Truck, four-wheel swing bolster, 32 in. diameter of wheels. Journals $5\frac{1}{2}$ in. diameter × 8 in. long.

Class K, Pennsylvania Railroad locomotives, were designed to run in opposition to the engine just described, and while they give very good results for an ordinary eight-wheel American locomotive, do not, I understand, equal in performance and economy all that might be expected of them.

The general design of these engines are probably so well known to the members of the Club as not to require description. Some of the dimensions are: Gauge of road 4 ft. 9 in. Cylinders 18 in. diameter × 24 in. stroke. Drivers 78 in. diameter. Driving wheel journals 8 in. diameter × $10\frac{1}{2}$ in. long. Total weight 92,700 lbs., or drivers 65,300 lbs. Wheel base rigid 7 ft. 9 in. Total, 22 ft. $7\frac{1}{2}$ in. Wagon top boiler 50 in. diameter, 201 tubes $1\frac{7}{8}$ in. diameter × 10 ft. $10\frac{1}{4}$ in. long. Fire-box 9 ft. $11\frac{7}{8}$ in. long × 3 ft. $5\frac{3}{4}$ in. wide. Grate surface 34.8 sq. ft. Heating surface in tubes 1,085 sq. ft. In fire-box 120 sq. ft. Total, 1,305 sq. ft. Engine truck, four-wheel rigid bolster wheels, 33 in. diameter. Journals $4\frac{3}{4}$ in. diameter × $7\frac{1}{2}$ in. long.

Turning next to the "Wootten" passenger locomotive, designed for the same service, we find the dimensions of Type D 33 to be: Boiler 53 in. diameter at smallest ring tapering back to $58\frac{3}{4}$ in. at joint of fire-box. Fire-box 8 ft. 6 in. long × 8 ft. 0 in. wide inside. Combustion chamber 31 in. long. 345 tubes $1\frac{1}{2}$ in. diameter × 9 ft. 2 in. long. Grate surface 68 sq. ft. Heating surface tubes 1,232 sq. ft. Fire-box 151 sq. ft. Combustion chamber 32 sq. ft. Total, 1,415 sq. ft. Cylinders $18\frac{1}{2}$ in. diameter × 22 in. stroke. Drivers 68 in. diameter. Rigid wheel base 6 ft. 5 in. Total wheel base 20 ft. $5\frac{1}{2}$ in. Stack 18 in. diameter. Weight on drivers 60,780 lbs. Total weight 89,750 lbs.

The "G. F. Ward," for the New York, Providence and Boston, and the 'Pegasus,' for the Boston and Lowell Railroad, will illustrate the best practice of the high speed engines of the R. I. Locomotive Works. These two engines are nearly alike, the dimensions being: Track gauge 4 ft. 8½ in. Cylinders 18 in. diameter × 24 in. stroke of piston. Boiler 52 in. diameter. 184 tubes, 2 in. diameter × 142¾ in. long. Fire-box 71¼ in. long × 34 in. wide. Drivers 72 in. diameter. Rigid wheel base 102 in. Total wheel base 279 in. Engine track, four-wheeled swing bolster wheels, 33 in. diameter. Weight on drivers 59,000 lbs. Total, 91,000 lbs.

The recently finished Mason Passenger Locomotive for high speed, designed by the Superintendent, John T. Meats, has attracted considerable notice in the Eastern States. In these engines care has been taken to increase the size of all wearing parts, new cylinders and all other working parts being carefully gone over, and we may expect from these engines as good performances as are possible to be got out of the standard American type. The dimensions are: Cylinders 18 in. × 24 in. Driving wheels 68½ in. diameter. Rigid wheel base 9 ft. Total wheel base 23 ft. 4 in. Weight in working order 102,000 lbs. On drivers 68,000 lbs. Boiler style, wagon top, 54 in. diameter. Material steel $\frac{7}{16}$ in. thick. 212 tubes 2 in. diameter × 11 ft. 2 in. long. Fire-boxes 78 in. long × 35 in. wide, 75 in. high. Driving axle journals 8 in. diameter × 8 in. long. Engine truck, four-wheeled swing bolster wheels, 30 in. diameter. Journals 5½ in. diameter × 11 in. long.

After the foregoing description of what has been done in the way of fast passenger locomotives of the standard American pattern, which are acknowledged by all as not filling the bill of what is required in these days of fast travel and heavy trains, the writer would beg to call your attention to the following design for a fast passenger locomotive. Would state in the beginning that there is to my best knowledge and belief nothing in this design covered by a patent, and if it is of use to any one, they are welcome to it. We do not claim anything absolutely original in this locomotive, all of the pieces for the most part being "old friends with new faces." The general plan is shown by the accompanying illustration. Some of the peculiarities of

this engine are, first, the twin fire-boxes. Boilers of this style were designed by Mr. E. D. Leavett, Jr., and built for the Boston Sewerage Engine, and are to-day giving first-class results. The only departure I have made from his design is in using the Belepare top, which makes a better arrangement of stays, and in the divided combustion chamber which gives a better circulation. Another departure from the American locomotive is in carrying the four-wheel truck entirely in front of the cylinder and connecting to the back driver. The object of this is to get the weight of the cylinders nearly all on the drivers, and so do away with that amount of dead weight, which in ordinary locomotives has to be carried, by placing no more weight on the front truck than is absolutely necessary to make the engine track well. In some cases a pony or two-wheeled truck might be used, but where high speed is required and the track is not perfectly straight, the danger of being derailed is so great with a two-wheeled truck in front, that not many American master mechanics would have the hardihood to use them.

With the style of truck here shown, the engine may be run with the same degree of safety as an ordinary eight-wheeled engine. This way of carrying the truck in front of the cylinders is very often used in the Old World.

General Specifications for a Fast Passenger Locomotive Engine.

General dimensions: Cylinders, 19 in. diameter, 24 in. stroke. Two pairs of coupled driving wheels 6 ft. 0 in. diameter, with a 4-wheeled swing bolster truck in front of cylinder and one pair of trailing wheels under fire-box back of drivers. Gauge of road, 4 ft. 8½ in. Fuel, hard or soft coal. Weight of engine in working order, 103,000 lbs.; on drivers, 87,000 lbs.; on truck, 10,000 lbs.; on trailing wheels, 5,000 lbs. Wheel base, driving 7 ft., rigid, 15 ft. 7 in. Total of engine, 29 ft. 2 in. Boiler, cylinder part and outside fire-box, of Otis steel, $\frac{7}{16}$ in. thick, riveted with $\frac{7}{8}$ in. rivets, placed not over 2¼ in. from centre to centre, all seams to be double riveted. Diameter at front end to be 60 in., made straight with one dome placed on middle of boiler, 32 in. in diameter, and 30½ in. high. Smoke-box, extended, 61½ in. in

diameter and $92\frac{1}{2}$ in. long, made of $\frac{3}{8}$ in. iron. Fire-boxes to be 8 ft. long, 46 in. wide at bottom, and 57 in. deep inside, made of steel. Crown, $\frac{3}{8}$ in. thick; sides, $\frac{5}{16}$ in. thick. Fire door sheet $\frac{3}{8}$ in thick. Combustion chamber, 38 in. deep, 52 in. wide and 42 in. long. Inside tube sheet, $\frac{1}{2}$ in. thick. The sides and crown to be stayed with $\frac{7}{8}$ in. stay bolts, screwed through and riveted over, placed not over $4\frac{1}{4}$ in. centre to centre. Water spaces, $4\frac{1}{2}$ in. front, $3\frac{1}{2}$ in. sides, tapering to $4\frac{1}{2}$ in. at crown, $4\frac{1}{2}$ in. in centre, tapering to 6 in. at crown. Tubes of iron, 200 in number, 2 in. O. S. diameter, No. 12, W. G. thick, 10 ft. 0 in. long, set with copper rings on fire-box ends.

Heating surface, tubes,	. . . . .	1040 sq. ft.
" " fire-box,	. . . . .	200 "
" " combustion chamber,	.	50 "
" " total,	. . . . .	1290 "

Smoke stack, straight, 18 in. diameter. Frames of best hammered iron 4 in. wide, with pedestal and braces welded in. Front rails bolted and keyed to main frames, and pedestals protected by cast iron wedges and shoes, the pedestal being connected at bottom by cast iron thimbles and bolts. Driving wheels, four in number, 72 in. diameter. Centres of best cast iron, with hubs and rims cored out, the centres turned to 66 in. diameter for tires to be shrunk on. Tires of best cast steel, 3 in. thick, both pairs flanged 6 in. wide. Driving axles of best hammered iron; journals, 8 in. diameter, 10 in. long.

IX.

THE SCHUYLKILL RIVER EAST SIDE RAILROAD COMPANY.

By C. W. Buchholz, Member of the Club.

Read May 16th, 1885.

Ever since the Philadelphia, Wilmington and Baltimore Railroad has been absorbed by the P. R. R. system, and since the decisions adverse to the interests of the P. & R. R. R., of the long

pending suits about the Junction Railroad, the P. & R. R. R. has been deprived of its influence in the Junction Railroad, and thereby of its railroad connections with the southern part of the city and with its own Chester Branch. These facts have made it of vital importance to establish a new link through Philadelphia, to offer connections not only to the interests above referred to, but also to the new line now building from Baltimore, which was called into being by the established monopoly of the Pennsylvania Railroad between these two important cities; a monopoly that virtually controls the traffic between the metropolis and the capital of this country. The Philadelphia Branch of the B. & O. R. R. now under construction and nearly completed to the county line of Philadelphia, has to find a way, not only through Philadelphia to New York, but also such a route as will give it ample facilities for business in Philadelphia, the second largest city in the United States. There is no other way to accomplish this object, except by a connection with either the P. & R. or the Pennsylvania Railroad. No money consideration could buy terminal facilities in Philadelphia as now enjoyed by either of these large corporations. As the new line from Baltimore is in opposition to the Pennsylvania Railroad, it seems to follow that it must find a suitable connection with the P. & R. R. R. In order to meet this demand the Schuylkill River East Side and the Schuylkill River West Side Railroad Companies were chartered in the interest of the P. & R. R. R. These lines were at once located, right of way settlements were commenced, and the plans were prepared for their construction. An unusual and violent opposition against the S. R. E. S. R. R., the line finally adopted, was at once started.

The opposition fought the location of the bridge over the Schuylkill River below Gray's Ferry before the Port Wardens; the question was carried over their decision, behind the Tug Boats Association, to the Courts. City Council was induced to object to the building of the proposed railroad; before Council knew of any just cause to object, the great boulevard scheme was resurrected and obstructive bills were filed to prevent the new road from crossing at grade the old P. W. & B. R. R. at Gray's Ferry, a road that has been virtually abandoned except for local freight pur-

poses. To meet all these groundless oppositions, the construction of the new railroad has been unnecessarily delayed, and although some of the much debated questions have been decided and settled in its favor, endless litigation is still in store for it, unless the citizens of Philadelphia by their overwhelming approval of the new line will silence and stop all further selfish interference. That the new line will be of infinite benefit to Philadelphia, is so self-evident that it need not be commented upon here; every business man must be aware of it. The only question at all open to fair discussion, is the one of location of the new line through the city. Is the line selected by the S. R. E. S. R. R. Co. the best that can be had by the P. & R. R. R. and by the B. & O. R. R.? If so, it is also the best for the traveling public and for the business men of Philadelphia, for their interests are identical with the railroads. And how does it affect the established highways and streets of the city and the adjacent properties? It is very evident that these questions cannot be answered by merely examining the topography of the city, nor by any of the ordinary methods that generally fix the locations of railroads in an open country. The fact that a new railroad is building from the south, and all the existing rights and franchises of the P. & R. must be taken into consideration and must be thoroughly understood before a clear and just decision can be arrived at.

A look at the map of Philadelphia will show at a glance that the line of the P. &. R. R. R. on Pennsylvania Avenue and Willow Street cuts the city in two from east to west, and forms the most southern piece of track, ignoring the Chester Branch, owned by the P. & R. R. R.

The New York Division and the Germantown and Norristown Railroad on Ninth Street strike these tracks at right angle, and are now connected by a curve of short radius for the transmission of freight. Keeping these facts in view, and remembering also that on these lines of the P. & R. R. R. now established for nearly fifty years, large manufactories have grown up and all the freight and passenger stations of the P. & R. R. R. are located, and considering further that business and travel have accustomed and adjusted themselves to these localities, then it becomes at once self-evident that the new line coming from the south must strike

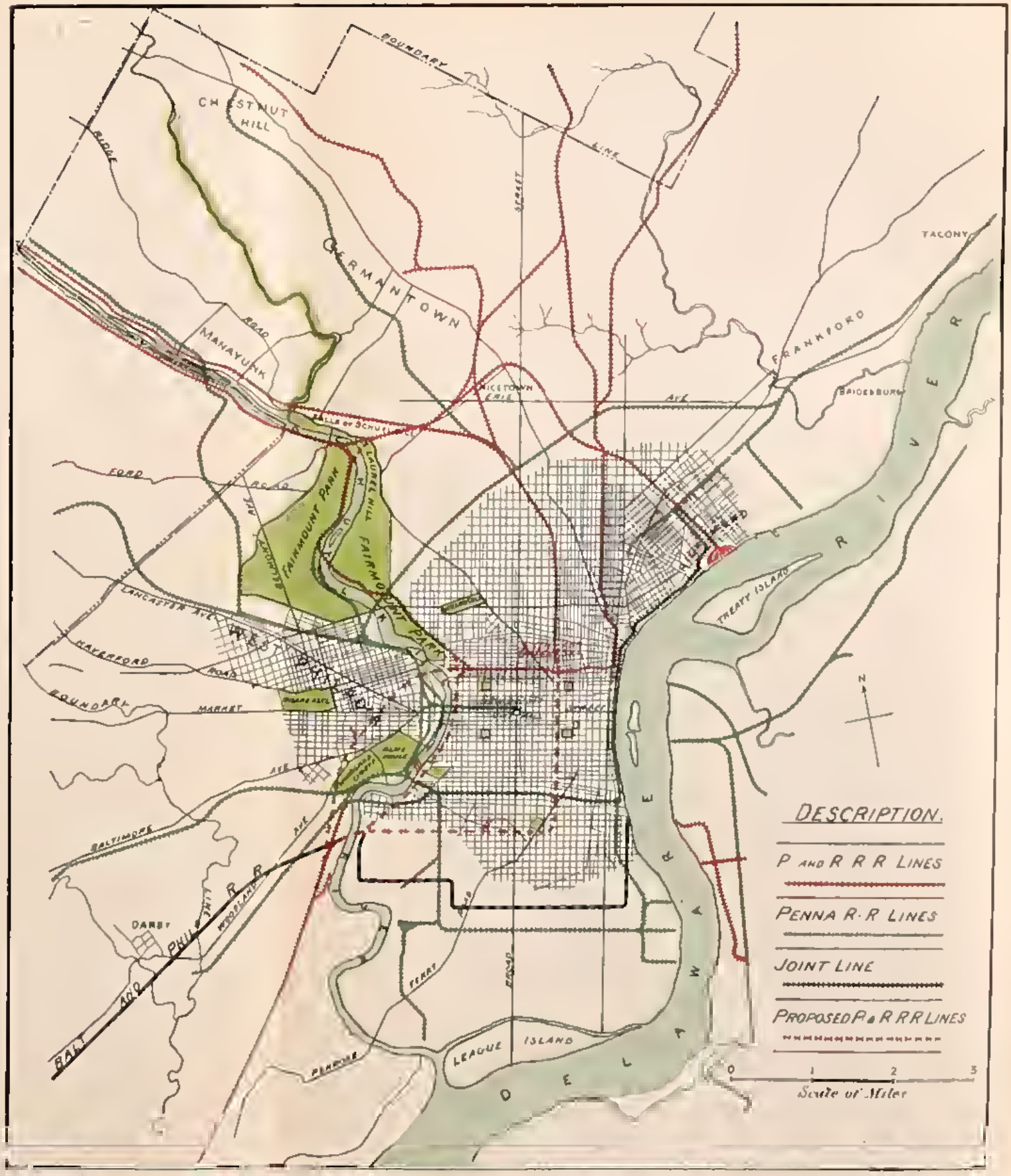
and connect with the P. &. R. R. R. somewhere between the Schuylkill and the Delaware on Pennsylvania Avenue or Willow Street. Three such lines are possible, and all of them have been surveyed and estimated. They have been carefully considered from their commercial point of view, as well as from the topographical view in relation to the streets and properties of the City of Philadelphia.

The first line considered and seriously thought of, left the Chester Branch of the P. & R. R. R. at about Fifty-eight Street, running almost due north, crossing Mill Creek at about Forty-fifth Street and Greenway Avenue. Thence after curving to the right by tunnel and open cuttings under West Philadelphia, emerging at Hamilton and Thirty-first Streets, crossing the latter street on grade. Thence over the yard of the P. R. R. and over the river to Twenty-first and Pennsylvania Avenue, going above all the streets between the Schuylkill and the point of connection with the P. & R. R. R. The excessive cost of this line, embracing a long tunnel and deep cuttings, a great number of bridges and an expensive viaduct over the yard of the Pennsylvania Railroad made it at once of questionable value. Further examination proved that some of the most valuable private properties in West Philadelphia occupied by the owners, would be entirely destroyed and others made useless as residences. The legal difficulties and the enormous cost to get possession of so great an amount of real estate might be overcome, provided there would be some future compensating profit anticipated by the establishing of large manufactories on the building sites destroyed. But there can be no such hope. This line passes through a part of West Philadelphia, made valuable only on account of its healthiness and on account of its beautiful surroundings, fitting it especially for residences, but entirely useless for large industries such as bring revenue to a railroad. The line was subsequently abandoned. A second location was then selected. This line leaves the Chester Branch near the same point where No. 1 does, but curving to the right it runs due east. After crossing the river it continues its course eastward parallel with and between Tasker and Dickinson Streets to about Tenth Street, where a curve to the left would begin to connect it with a line continued

from Green Street, running south between Eighth and Ninth Streets and parallel with the same.

A railroad built upon this line, all of it elevated above the streets, would probably give to the B. & O. and to the P. & R. R. R. all that they would desire for a through connection at present, but an enormous cost, involving the destruction for squares of the best property for retail business and handsome stores in the city, without giving either to the city and its property owners, or to the railroad company corresponding advantages for other enterprises or hope for future profits, except, perhaps, that a passenger depot located near Eighth and Market Streets would probably be the most convenient, at least for the next ten years, to the traveling business public. But Eighth and Market, or Eighth and Chestnut Streets are hardly now and certainly will not be in the future, either the centre of commerce or the centre of population. All the retail business is moving westward, and it will not be many years when the whole belt of the City of Philadelphia between Second and Twentieth Streets and between Pine and Callowhill Streets will be one mass of stores and offices without any private residences of importance.

All these must move to West Philadelphia or to the north; the southern portion of the city being too low and is not looked upon as healthy. The wholesale trade and manufactories will always remain along the river, and that trade is already amply provided on the Delaware with railroad facilities. The Delaware River Front Railroad sweeps along the wharves of the river from League Island to Richmond, and connects with all the railroads entering the City of Philadelphia. But the Schuylkill River has no railroad facilities on the east or city bank, and there are to-day no better sites in Philadelphia for the establishment of large manufactories and wholesale business in general than the river front from Gray's Ferry to Callowhill Street. All the properties over that entire distance between Schuylkill Avenue and Twenty-fourth Street on the east, and the river on the west are entirely unfit for residences, but cannot be surpassed for the location of cotton or rolling mills, blast furnaces, marble and coal yards or other large establishments, provided a competing railroad would be added to the water facilities already existing.


BOUNDARY
LINE
CHESTNUT HILL
RIDGE
GERMANTOWN
MANAYUNK
ROAD
MARKET
TACONY
FRANKFORD
BRIDESBURG
NICETOWN CREEK
AVE
FORD
ROAD
FAIRMOUNT PARK
LEVERING HILL
LANCASTER AVE
RAILROAD
ROAD
BOUNDARY
MARKET
AVE
BALTIMORE
AVE
DELAWARE RIVER
TREATY ISLAND
DARBY
PHILADELPHIA & BALTIMORE R.R.
FERRY
ROAD
LEAGUE ISLAND
PENROSE
DESCRIPTION.
P AND R R R LINES
PENNA R·R LINES
JOINT LINE
PROPOSED P & R R R LINES
0 1 2 3
Scale of Miles
N

S. R. E. S. R. R. CO. ETC.

These facts I have no doubt led to the abandonment of line No. 2, and induced the P. & R. R. R. Co. to project and order the location of the Schuylkill River East Side Railroad. This line connects with the Philadelphia Branch of the B. & O. R. R. at about the same point where lines Nos. 1 and 2 started, and after curving to the northeast and crossing over the P. W. & B. R. R. and over the Chester Branch of the P. & R. R. R., with which it connects at a lower level, it crosses the Schuylkill River somewhat diagonally, about 1,200 ft. below Gray's Ferry Bridge, and at a height of 30 ft. clearance above mean high water. Continuing on the same straight line and with a descending grade it crosses the old P. W. & B. R. R. and Gray's Ferry Road at about Thirty-fifth Street and passes under the Delaware Extension of the Pennsylvania Railroad between the abutment of the Arsenal Bridge and the Port Wardens' line of the river. This latter line the railroad follows never less than 30 ft. from the bulkhead and at an elevation of about 3 ft. above the city datum to about Arch Street. From there the line begins to curve to the east and continues on that curve with a heavy ascending grade to its connection with the P. & R. R. R. near Twenty-first Street. Gray's Ferry Road and Twenty-first Street are the only two highways crossed on grade by this proposed railroad, three miles in length. The Gray's Ferry grade crossing can be avoided if imperatively necessary, and Twenty-first Street will be crossed overhead eventually when the projected readjustment of grades on Pennsylvania Avenue and the streets that cross it has been consummated. All the other streets crossed by the S. R. E. S. R. R. go over it or terminate on the Schuylkill and are not thoroughfares, or unopened, and can be so adjusted when opened as to go over or under the proposed railroad. Not one of the objections urged against the first and second line can be maintained against the S. R. E. S. R. R. All the properties through which it passes will be improved and not destroyed, and will become valuable to the owners and a source of future business to the railroad company. The line will not be a nuisance to adjoining residences, because nobody will live or does now live within several squares of it; it will not at all interfere with the travel of any street railway, pleasure carriages or pedestrians, and to a small extent only with

such vehicles as are now required to go to railroad depots and freight stations, and to which the crossing of a few tracks is not a nuisance or danger.

It is contemplated to make the connection on Pennsylvania Avenue with a Y running east and west, so that through trains can be run via Ninth and Green Streets, making a connection at Ninth and Willow, or via Belmont and West Falls. The re-adjustment of grades on Pennsylvania Avenue, Willow Street and Ninth Street to avoid grade crossing has long ago been thought of by the P. & R. R. R.; detailed plans were prepared twelve years ago, and these improvements must follow the construction of the S. R. E. S. R. R. within a short time. When all this has been accomplished, with the principal depot erected at Twenty-fourth and Chestnut Streets, Philadelphia will possess a completed line of railroad running the whole length of the city, from north to south, from Chestnut Hill to Gray's Ferry, a distance of fifteen miles, not only capable of carrying passengers and freights through to any part of the United States, but also of an immense local advantage to the southern part of the city.

P. S.—Since the above was read before the Club the line of the S. R. E. S. R. R. has been adopted with very few changes in its alignment and the R. R. is now under construction.

The Schuylkill River is nearly the geographical centre line of the city, and it is believed that within ten years the proposed depot at Twenty-fourth and Chestnut Streets will be nearer the centre of population and trade than Broad and Market is now.

X.

STEREOGRAPHIC PROJECTION—PRACTICAL METHODS.

By Prof. L. H. Barnard, Member of the Club.

Read June 6th, 1885.

Spherical projections may be subdivided into Orthographic and Scenographic. In the former the point of sight is at an infinite distance; in the latter at some finite distance. If the point

of sight be taken at either pole of primitive circle the projection becomes Stereographic. The following practical methods, based upon the fundamental theorems of Stereographic Projection, are such as have suggested themselves while teaching the subject.

The following are the more important theorems upon which the constructions I shall give are based:

A—All circles of the sphere project as circles, except when the plane of circle passes through the point of sight, and when the polar distance is equal to the supplement of the inclination.

B—The Stereographic projection of any point of the sphere is at a distance from the centre of the primitive circle equal to the tangent of one-half its polar distance.

C—If a plane be passed through the axis of a given circle of the sphere, and the axis of the primitive circle, it will intersect the plane of the primitive circle in a line called "the line of measures" of the given circle. It follows from this definition, that the line of measures passes through the centre of the primitive circle, and is perpendicular to the intersection of the given with the primitive circle.

D—If a small circle be perpendicular to the primitive circle, the centre of its projection will be on its line of measures, at a distance from the centre of the primitive circle equal to the tangent of its polar distance.

E—The centre of the projection of a great circle will be on its line of measures, and at a distance from centre of primitive circle equal to the tangent of its inclination.

F—If the inclination of a given circle of the sphere to the primitive circle be called I, and its polar distance d, then the extremities of its diameter are distant from the centre of the primitive circle by an amount equal to tan. $\frac{1}{2}(I + d)$ and tan. $\frac{1}{2}(I - d)$.

G—The angle between two circles of the sphere which intersect, is the same as the angle between the projections of their tangents at the points of intersection; also the same as the angle between the lines drawn from the projection of their points of intersection to the centres of their projections. The angle between two intersecting circles is equal to the angular distance between their poles.

Constructions.

Principal diameters: The diameter drawn through any point, and the one at right angles to it, may be called the principal diameters.

The plane of the primitive circle is considered to be a vertical plane, and the horizontal and vertical diameters are usually taken as the principal diameters.

1. To find the locus of all points having the same polar distance:

Let C (Fig. 1) be the centre of primitive circle. AB and DE be the principal diameters; lay off the arc Bp equal to the polar distance. Draw Ap intersecting DC in P. With C as a centre and CP as a radius describe a circle PGH. This is required locus.

2. To project a circle given the pole and polar distance:

Three cases arise, the construction for each depending upon theorem F.

Case 1.

When the pole falls within the primitive circle:

Let P (Fig. 1) be the pole. Draw the diameter DE through P, also AB at right angles to DE. Draw AP, and produce it to intersect the primitive circle at p. Lay off pm and pn equal to the polar distance of the circle. Draw Am and An, intersecting DE in M and N. MN will be the diameter of the required projection. Bisect it at O, and describe the circle MSN. It is readily seen that Bm equals $Bp + pm$ (inclination + polar distance), and that Bn equals $pn - Bp$ (equals inclination — polar distance).

Should the polar distance of the circle be greater than the arc pD, the construction would be similar; the point M falling outside of the primitive circle. This is shown in lower half of Fig. 1; $NS'M'$ being the projection of such a circle.

Should the polar distance be the supplement of the inclination of the required circle, the point m would fall at A, and Am would become parallel to the diameter DE, and intersect it only at an infinite distance. Hence the radius becomes infinite, and the projection of the circle a straight line. To illustrate this, let P'' be the pole of a circle, whose polar distance equals $p''A$, lay off $p''n'$ equal to $p''A$; draw An', intersecting DE in M''. Then

$M''S''$ drawn perpendicular to DE will be the required projection. Should the required circle be parallel to primitive circle, then its projection is concentric with it. PC becomes zero. The radius will equal the polar distance of the circle.

If the required circle be a great circle the construction becomes as follows (see Fig. 2); viz.: Let P be the pole; draw AP and produce to p, then pB equals the inclination of required circle. Now draw arc CG with A as a centre, and AC as radius, and lay off CG equal to inclination, equal to pB, draw AG and produce to intersection with $P'E$ at O, and the primitive circle at B'. O will be the centre of required projection. (See Theorem E.) Since it is a great circle it must pass through A and B. Hence with O as centre, and OA as a radius, draw ASB. It will be the required projection.

The following is another and shorter construction: Lay off pB' equal to pB; draw $B'A$, it will intersect $P'E$ at O, the centre of required projection.

Case 2.

When the pole of the required circle falls on the circumference of primitive circle:

Let P' be the pole of the required circle (see Fig. 2), and $P'E$ and AB the principal diameters. Lay off $P'n$ and $P'm$ equal to the polar distance; draw Am and An, thus determining M and N the extremities of the diameter of the projection as in Case 1. The following construction is shorter, however: Since the required circle is at right angles to the primitive circle, the lines drawn from the centre of each to the point where they intersect must be at right angles to each other. (See Theorem H.) Hence from P' lay off $P'm$ equal to the pole distance of the circle. m is one of the points in which the circles intersect. The centre of the required circle lies on the line EP', since EP' is its line of measures. The centre will therefore be found by drawing a tangent to the primitive circle at m, and finding its intersection with EP' at O. Then with O as a centre and a radius equal to Om, draw the circle Mmn.

Case 3.

When the pole of the required circle falls outside the primitive circle:

Determine the extremities of the diameter as in Case 1, and describe the circle upon it. Fig. 3 illustrates the construction.

3. To find the locus of all great circles that pass through a common point:

Let M be the given point (see Fig. 4). Draw AM and produce it to find m. All great circles passing through M must also pass through a point 180° from M. To find this point lay off mn equal to 180°. Draw An and produce it until it intersects DE in N. N is the projection of a point 180° from M. MN is therefore a diameter common to all the great circles passing through M, and the centres of their projections will fall in the line GOH, drawn at right angles to MN through its middle point O.

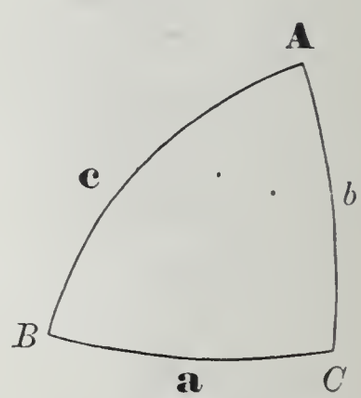
A shorter construction is as follows; viz.: Lay off Bm' equal to $2mD$; draw Am' and its intersection with DE will give the point O. Bm' being two Dm, and Dm being the inclination of the circle through M at right angles to DE; so that CO is, by construction, equal to the tangent of the inclination. (See Theorem E.) Then through O draw GOH as before. With O as a centre and OM as a radius, draw the circle AMB at right angles to DE. To find the centre of the circle that makes any angle X with DE, draw a line MO', making CMO' equal to the angle X; the intersection of this line with the locus HG at O' gives the centre of required circle; then with O' as a centre, and a radius $O'M$ draw the required circle MSQ.

Projection of the Spherical Triangle.

In the six cases that may arise in the solution of spherical triangles, I have selected three, to illustrate the application of the constructions given to the projection of the spherical triangle.

Case 1.

Given A 105°, c 30°, a 75°.



Place A at the centre of the primitive circle (see Fig. 5), two

sides of the triangle will then project as straight lines passing through the centre of the primitive circle, making an angle of 105° with each other. Lay off MAC equal to one 105°. This projects the angle A. Lay off AB equal to c, equal to 30°. Then if with B as a pole, and polar distance equal to the value of the remaining side a, or 75°, a circle be projected, the intersection of this circle with PQ will determine the third vertex C. CLC' is this circle. It intersects PQ in two points: C and C', thus giving the two solutions. The centres of the arcs BC and BC' are found by constructing the locus of all great circles passing through a common point, B. This gives the line DF. Then repeat the same construction for C and C'; this will give the lines $O''''H$ and SV. The intersections of $O''''H$ and SV with DF determines the centres O''' and O'''', since if a point lies on two lines it will lie at their intersection.

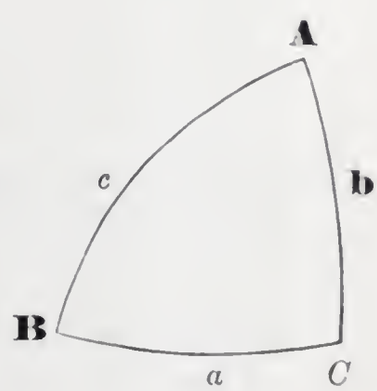
The perpendicular required by Napier's Rules would be drawn from B to side b; the centre of this circle lies on PQ, since it is at right angles to it, and also on DF, hence at their intersection. It may fall outside of the drawing, as in the present instance.

Suppose, however, that Bp is this perpendicular. Then, in solving by Napier's Rules, the side b is obtained by solving for Ap and Cp. Then b equals $Ap \pm Cp$. This is very clearly shown in the figure. Since BC equals BC', CBC' is isosceles, and Cp equals $C'p$, and CA equals b, equals $Cp—Ap$, also $C'A$ equals $C'p+Ap$, equals $Cp+Ap$.

The projection of a triangle will often enable one to decide whether an angle or side is greater or less than 90°, and being a graphical representation, it shows at a glance the relations of the several parts of the triangle, especially where two solutions occur.

CASE 2.

Given A equal to 105°, b 52° 30′ and B 60°.

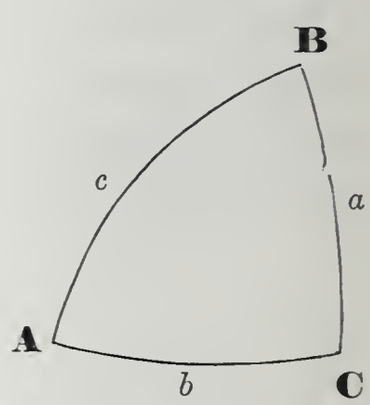


Put A at the centre (see Fig. 6). Draw the principal diameters, EF and CD. Lay off EAQ equal to 105°. Find projection of vertex C, by theorem B. Now construct the polar triangle of the given one as follows: From the definition of polar triangle it is evident that C' is one vertex and B'' another, hence $C'B''$ is one of its sides. If with C as a pole, the great circle $B''A''A'$ be described, it will give the direction of another side, and since the sides of the polar triangle are the supplements of opposite angles in the required triangle, the length of third side must be equal to 180°—60°, equal 120°.

If then with C' as a pole, we project a circle of polar distance 120°, the third vertex will lie on it, but it also lies on $B''A''A'$, hence the following construction. Lay off $C'W$ equal to 120°; draw a tangent WO', and since $C'D$ is the line of measures of the required circle, O' will be its centre and $O'W$ its radius. Draw $WA''A'$; it intersects $B''A''A'$ in A'' and A', giving two solutions, $A''C'B''$ and $A'C'B''$, hence the required triangle has two solutions. The centres O'' and O''' of arcs $C'A''$ and $C'A'$ lie in EF and LM, and are found by drawing a perpendicular to the chords DA'' and DA'. The third vertex of required triangle is found by projecting two circles, with A'' and A' as poles, and a polar distance equal to 90°; the centres of these are O''''' and O'''', and the two solutions are ACB and ACB'.

Case 3.

Given A 75°, B 60° and C 120°.

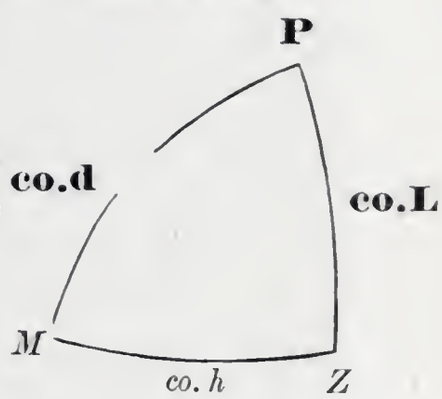


Place A at the centre of the primitive circle, Fig. 7, and so project the triangle that C will fall on vertical diameter through the centre and above, and B to the left. Construct FAV equal to 75°; draw $C'W$ at right angles to VA. Then B' and C' are vertices of the polar triangle, and $B'C'$ one of its sides. The remain-

ing sides will be equal to 180°—B, and 180°—C, or 120° and 60°. If, then, with B' and C' as poles, circles be projected with polar distances of 60° and 120° respectively, their intersection will determine the third vertex of the polar triangle. The tangent lines DO and KO' determine the centres O and O' of these circles. Then with radii OD and $O'K$ draw arcs intersecting in A', the third vertex of polar triangle. Finally, with A' as a pole and a polar distance of 90 degrees, project a circle. The construction is: Draw RQ at right angles to NP. Draw RA' and produce to V; lay off VY equal to VQ; draw RY intersecting NP in O'', the centre of required projection. Then with radius $O''Q$ draw CQB. ABC is the required triangle. The required angles of any triangle may be measured by drawing the tangents to the intersecting circles; the sides may be measured by projecting the polar triangle and measuring its angles in the same manner.

Projection of the Astronomical Triangle.

Given Lat. 30° N., the declination of a heavenly body 45° N., and its hour angle 45° W.



Let P be the pole of the heavens, Z the zenith, and M the body. Then, as indicated in the diagram, we have given two sides and the included angle. Let it be required to project it on the plane of the meridian. Let ZNS, Fig. 8, be the primitive circle; Z is the zenith; Na the nadir; N and S the north and south points; E and W the east and west points, the east point being the point of sight. Construction: Lay off ZP equal to the co-latitude, equal to 60° N. QE is the locus of centres of all great circles passing through the point P. The centre of the one making an angle of 45° with the primitive circle is at E. Then, with E as a centre and EP as a radius, draw PC. This will be another side of the required triangle. Since the length is *co-d*, or 45°; if, with P as a pole and a polar distance of 45°, a circle be projected,

it will intersect *PC* 45° from *P*, thus determine the vertex *M*. In this case the pole is on the circumference of the primitive circle. Lay off *Pm* equal to 45°, draw a tangent to the primitive circle at *m*, and its intersection with *WP* at *M'* gives the centre. Then, with radius *M'm*, draw *mD*, intersecting *PC* at *M*. Now pass a great circle through *Z* and *M*. This is most readily done by drawing a perpendicular to the chord *MZ* at its middle point and finding its intersection with *NS* at *O*. With *O* as a centre and a radius *OZ*, draw *ZM*. *PZM* is the required projection.

To project the same triangle on the plane of the horizon:

Let *NWSE*, Fig. 9, be the primitive circle. *Z*, the zenith, will be the centre, and the nadir the point of sight. Construction: Lay off *ZP* equal to co-latitude, equal to 60°. *AB* is the locus of all great circles passing through *P*. Draw *PO*, making *OPZ* equal to 45°; then, with *O* as centre and radius *OP*, draw *PM*. Then, as in preceding construction, project a circle with *P* as pole and polar distance equal to side *PM*. Then join *MZ* by a straight line. *PZM* is the required triangle.

As a further illustration, the following problem is given: Let it be required to project the sphere on the horizon of a place in 30° N. latitude and 0° longitude, showing the meridians 45° and 90° east and west; the parallels, 30° N. and 60° N. and 30° S., project the equator and join the point *A* (lat. 60° N. and long. 90° E.) with the point *B* (lat. 30° S. and long. 45° E.).

ENWS, Fig. 10, is the horizon, *N* the north point, *E* the east, etc. The zenith *Z* falls at the centre. *P* is the elevated pole, 60° from *Z*. All meridians pass through *P*; hence, to project any meridian, find *O'O''*, the locus of the centres of all great circles passing through *P*. *O'PED* is the one 90° E. and 90° W., with centre at *O*; *PBD* and *PGD* are the ones 45° E. and 45° W., with centres at *O'* and *O''*, respectively. The parallels 30° N. and 60° N. are projected with *P* as a pole, and a polar distance equal to 60° and 30°, respectively. The parallel 30° S. projects into the line *O'O''*, since its polar distance is equal to the supplement of its inclination. The points *A* and *B* are joined by finding the locus of all great circles passing through *A* and *B*, and taking their intersection at *O'''''*, as the centre, and the radius *OA*, and drawing the arc *AB*.

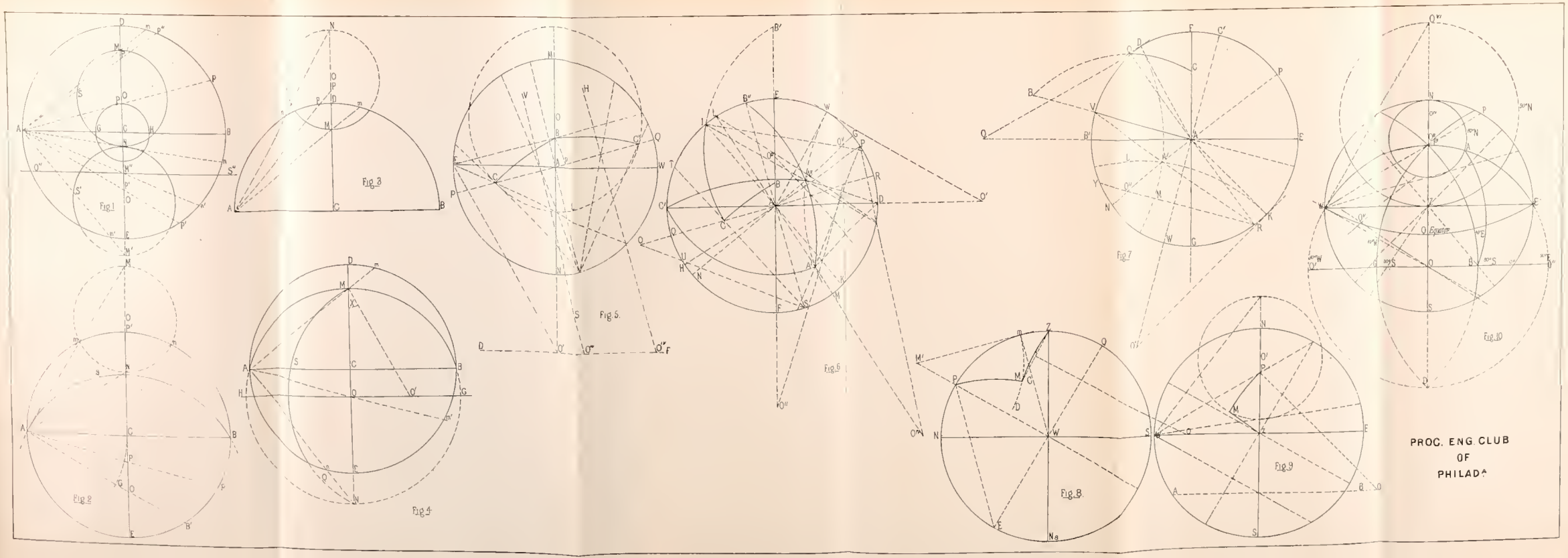


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5.
Fig. 6
Fig. 7
Fig. 8.
Fig. 9
Fig. 10
Equator
PROC. ENG. CLUB
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XI.

THE SAND-BAG EMBANKMENT ACROSS LITTLE INLET, BRIGANTINE BEACH, N. J.

By Percy T. Osborne, Member of the Club.

Read June 6th, 1885.

The following paper upon the construction of a sand-bag embankment to close Little Inlet, Brigantine Beach, N. J., has been prepared by request from data furnished by the engineer, Mr. Richard B. Osborne.

Brigantine Beach runs northeastwardly for 8½ miles from Absecom Inlet to New Inlet, which opens into Grassy Bay.

It was designed to establish on this beach, 3¼ miles from Absecom Inlet, a bathing resort to be called North Atlantic City. This strip of beach land, at a point 1¼ miles north of Absecom Inlet, was cut by an inlet, through which the tides freely flowed into Wading Thoroughfare and Grassy Bay. To afford easy access to Atlantic City the projectors of the new scheme desired to have this inlet filled up. The well authenticated fact of the changing character of this shore, produced mainly by the northeasterly winds, seemed to promise a quicker solution of a problem that would, under natural laws alone, require a century or more to work out.

If Nature's forces could be brought into more active operation it was certain that the law which had controlled her heretofore would not be reversed, and that therefore any action on her part would be as a co-worker in the closing of this channel. This had already been accomplished with this very inlet when its site was half a mile further north—the sea filling up the old channel and excavating for itself a new one. The same results have taken place with Absecom Inlet, which has been moved by the sea from its former locality, at Peter's Beach, and now occupies what a century and three-quarters ago was heavily timbered land. There was, therefore, as a guide, a controlling law that no efforts of man could alter, and which indicated that every cubic yard placed in the way of its natural action, would best expedite

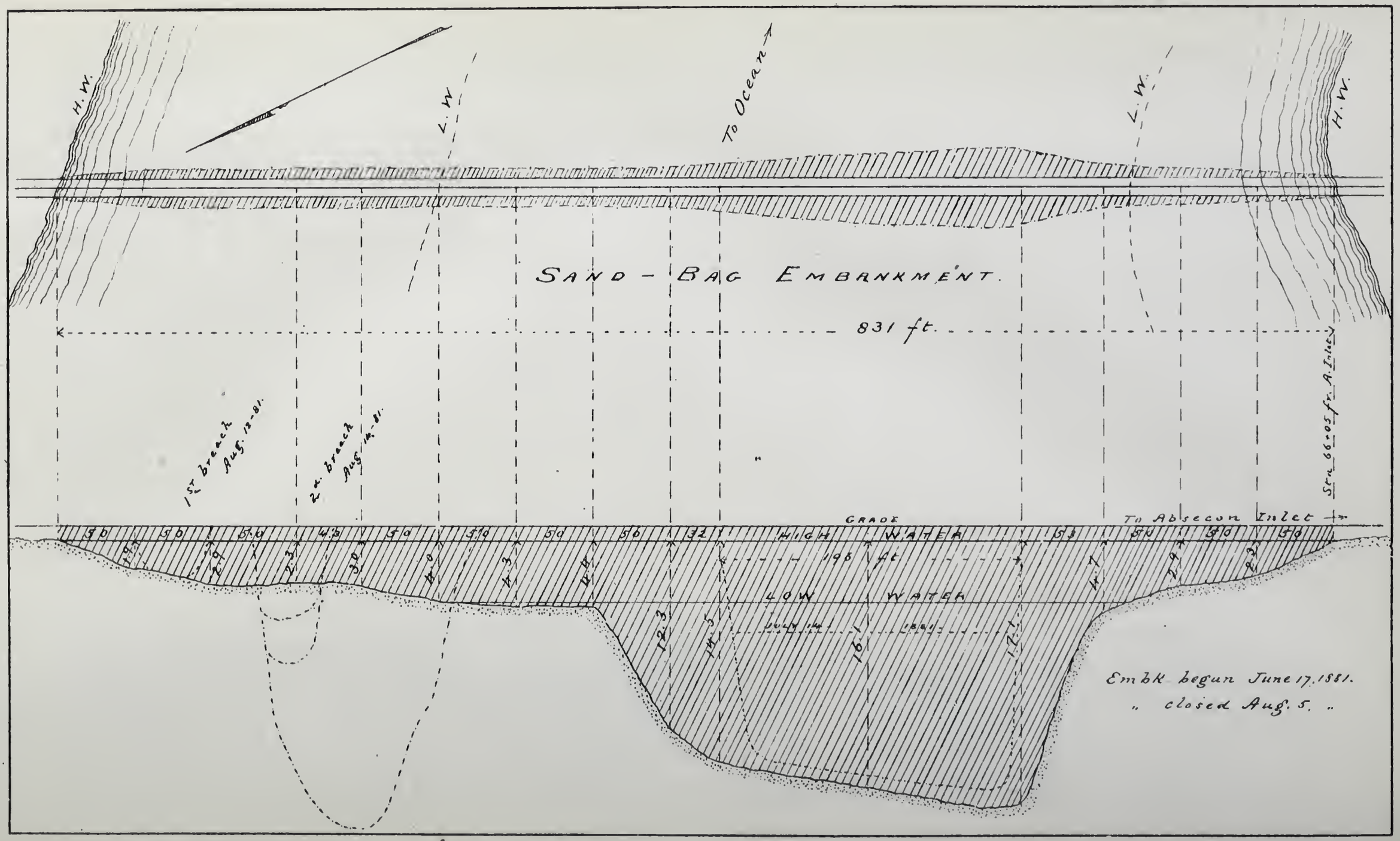
its certain fulfilment. These were the principles upon which this work was conducted. Prompt action to afford Nature an opportunity to produce equally prompt results was necessary from the material at the disposal of the engineer, which was solely extremely fine sand.

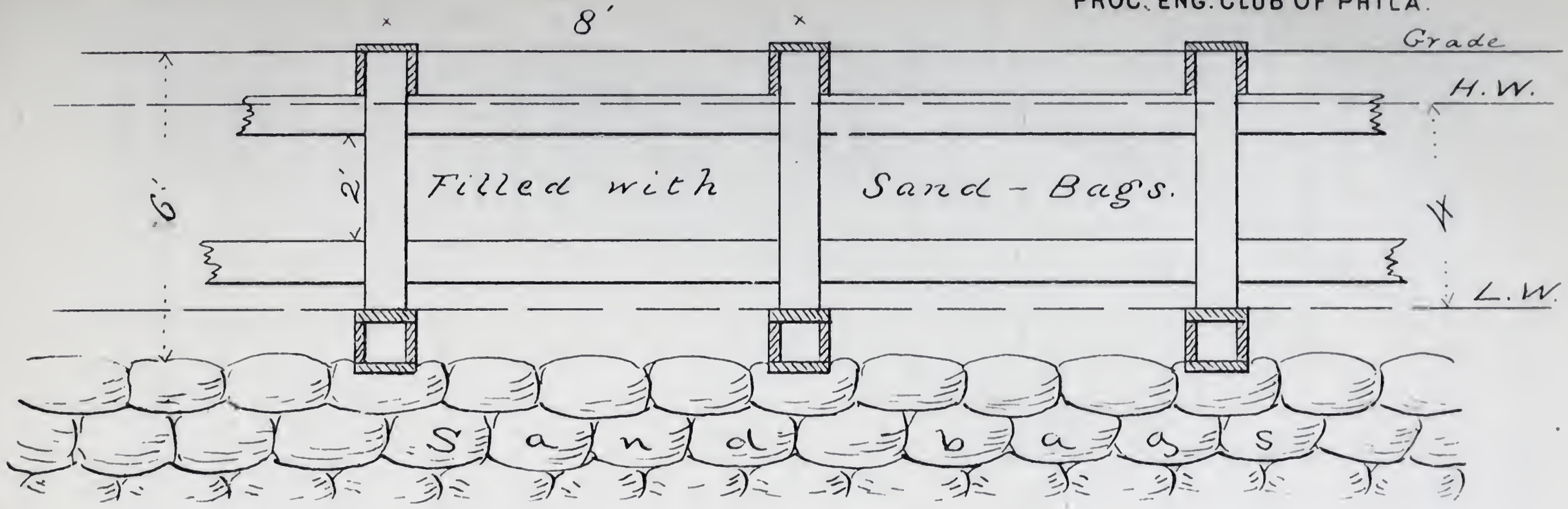
The only possible available way of using it was to pack it closely in bags and carefully sew them up. These should have been made of very close material, but those supplied were the ordinary salt bag, costing $5\frac{1}{2}$ cents apiece, and containing when packed $2\frac{1}{4}$ cubic feet each. In consequence of waste through the interstices they were not fully effective, yet it was interesting to notice the heavy surf, during storms, break on them and leave them unmoved, and even more consolidated where masonry would have yielded and been displaced.

Bags of sand were left over night at the ends of the embankment exposed to every wave and numbered with red chalk, but not a bag was missing in the morning, though the constant action of the surf tended to thrash out some of the sand.

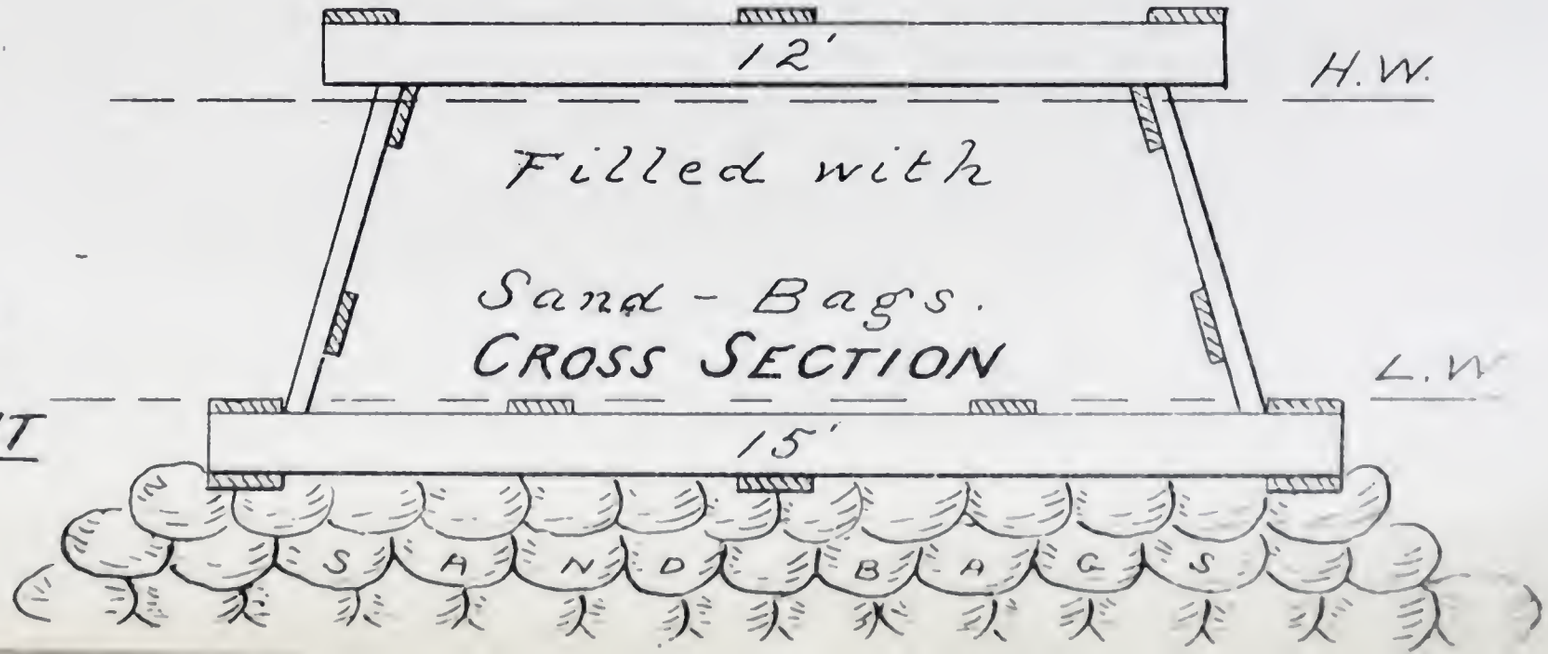
The profile and plot exhibit the extent and character of this inlet when operations on it commenced, and also the embankment as completed. The width of water increased on closing from 831 ft. to 1,000 ft. at high tide. The bags were filled within 100 yards of the embankment. Seven wheel-barrows, each loaded with one bag, deposited 1,050 bags in the day of ten hours, or 105 per hour. It required twelve of these bags to make one cubic yard. The *cost* per cubic yard in place amounted to one dollar—66 cents being cost of bags and 34 cents for filling, sewing, placing, etc. From time to time measurements and soundings were carefully made to ascertain what influence the work had had upon the action of the sea, and every test gave convincing proof that it was fulfiling the expectations.

The mode of construction was by working from half ebb to about half flow of tides. Bags were given direction by hand and permitted to sink with as much regularity as possible to form layers at the base of embankment, and these were built up within one foot of low water and the top leveled. On these bags as a foundation, frames (like model), about 6 ft. in height and 12 ft. long on top, were placed. They were made of 2 and 3-in. planks


H. W.
L. W.
To Ocean
L. W.
H. W.
SAND - BAG EMBANKMENT.
831 ft.
1st Breach Aug. 12-81.
2d Breach Aug. 14-81.
Sta. 66+05 fr. A. Inlet
GRADE
To Absecon Inlet
HIGH WATER
196 ft
LOW WATER
Embk begun June 17, 1881.
" closed Aug. 5. "



FRAMING USED IN SAND BAG EMBANKMENT



and put 8 ft. apart, their sloping edges being connected by planks running longitudinally and 2 ft. apart. The space between the frames was filled with sand-bags, which were thus confined to their proper position.

The foundation layers were put down in stretches of 40 to 50 ft. from each shore, leaving the flow of water in the remainder of channel unchecked. On this foundation the embankment was raised to its full height within the frames, while the foundation bags were being again advanced toward mid-channel.

The work was started June 17th, 1881, and by 14th July following only 196 ft. remained to be completed, the foundation bags for this distance being within 2 ft. of low water.

In mid-channel at low tide the depth of water when starting was 13 ft., and as the embankment encroached on it, the current at the ebb and flow was about 8 ft. per second. It was therefore difficult to prevent the bags, when lowered, from being washed from position and scattered. To obviate this in some degree, an old scow was filled with 200 bags and sunk in mid-channel. This formed a nucleus for the remainder. Had the means permitted, a row of high poles along the base on each side would have been used to confine the bags dropped by hand, but without these facilities the work had to be pushed, as dispatch was an important factor in the success of the undertaking. On 4th August, the central space was reduced to 40 ft., bags were accumulated on each side, and at ebb tide on the 5th, the last opening was closed, and the sea effectually shut out in 42 days' work.

For nine days the embankment withstood heavy seas and strong southeast gales. About 1,000 bags had been reserved for repairs. On 12th August, a breach 50 ft. in length was made by the sea, where the water was about 2 ft. deep, 134 ft. from north end. Additional bags and planks, ordered on 6th August, were not supplied for 18 days. In the meantime, on 14th August, a second break occurred, which for want of the supplies could not be repaired. On the day they did arrive the contractor's forces were withdrawn by order of the president of the company, and the works were thus left to the mercy of the winds and waves, the breach increasing by 16th September to 132 ft. On 19th September, the company brought the works to a stand.

During the nine days it was closed the accretion from the sea had filled the channel, where 13 ft. of water formerly existed, so that it was covered at low tide by less than 2 ft., and for the whole distance from the embankment to low water mark of the ocean, 2,000 ft., the measurement was made on dry land at low tide, which was before at that stage always under water. Beyond low water mark three bars had been formed, distinctly seen on the flow of each tide. These indications gave a fair assurance that the impediment secured by the works already formed, even despite the breach, would ultimately heap the sand from the sea over the whole area, and this assurance was given by the engineer in his final report.

The action was even more prompt and perfect than he anticipated, and the whole area is now covered by the accretion to such a depth as to have changed the entire aspect of the locality. It has reclaimed some 70 acres on the side next the sea, and about 30 on the bay side.

The experience gained indicates that with close material for bags and a few appliances for their temporary protection, the system is capable of achieving results that no other method, with the like outlay, ever could accomplish. 80,000 bags of sand were used in this embankment.

XII.

RELATIVE COSTS OF FLUID AND SOLID FUELS.

By James Beatty, Jr., Member of the Club.

Read June 20th, 1885.

During the past twenty-five years there have been numerous efforts to introduce fluid fuels as substitutes for coal, for the evaporation of water in boilers, metallurgical operations, and, on a small scale, for domestic purposes.

The advantages claimed for these fuels are: Reduction in the number of stokers; one man being able to do the work of four

using solid fuel. Reduction in weight, amounting to one-half, with the better classes. Reduction in bulk; for petroleum amounting to about thirty-six per cent., and with the gases, depending on the amount of compression. Ease of kindling and extinguishing fires, and of regulation of temperature. Almost perfect combustion and cleanliness.

Siemens used gas, distilled from coal and burnt in his well-known regenerative furnace.

Deville experimented with petroleum on two locomotives running on the Paris and Strasbourg Railroad.

Selwyn experimented with creosote in a small steam yacht, and under the boilers of the steamship "Oberlin."

Holland experimented with water-gas in the furnace of a locomotive running on the Long Island Railroad.

Isherwood experimented with petroleum under the boilers of United States steamers.

Three railroads in Russia are using naphtha in their locomotives, and steamers on the Volga are using the same fuel.

Wurtz experimented with crude petroleum in a re-heating furnace at Jersey City.

Dowson, Strong, Lowe and others have devised systems for the production of water-gas.

These experiments, in general, have produced excellent results when considered merely in the light of heat production, but, in advocating their systems, the inventors seem to have overlooked the all important item of cost.

It is the object of this paper to show the impracticability of such systems when considered from a commercial standpoint, so long as the supply of coal lasts, and prices keep within reasonable limits.

In many cases, authors on the subject have given purely theoretical results, without allowing for losses in the furnace.

The fuels to be considered, are, anthracite and bituminous coals, crude petroleum, and coal, generator and water gases.

The average compositions of these fuels (considering only the heating agents), as deduced from the analysis of eminent chemists, are:

PERCENTAGE BY WEIGHT.

	C	H	O	CO	CH_4	C_2H_4
Anthracite,	87.7	3.3	3.2			
Bituminous,	80.8	5.0	8.2			
Petroleum,	84.8	13.1	1.5			
Coal gas,		6.5		14.3	52.4	14.8
Generator gas,		1.98		35.5	1.46	
Water gas,		6.3	.6	87.8	1.2	

We will employ the formula of Dulong

$$h = 14500\ C + 62000\left(H - \frac{O}{8}\right)$$

to compute the theoretical heating powers of these fuels. In the case of Methane, CH_4, the formula is not true, but the error is not great enough to seriously affect the result. This gives, for the combustion of one pound of

Anthracite,	14500	Br.	Heat	Units.
Bituminous,	14200	"	"	"
Petroleum,	20300	"	"	"
Coal Gas,	20200	"	"	"
Generator Gas,	3100	"	"	"
Water Gas,	8500	"	"	"

Reducing the above to terms of pounds of water evaporated from 212° F., we have:

POUNDS OF WATER EVAPORATED FROM 212° F.

Anthracite,	15.023
Bituminous,	14.69
Petroleum,	21.00
Coal Gas,	20.87
Generator Gas,	3.21
Water Gas,	8.7

The results of experiments show the efficiency of fluid-burning furnaces to be about ninety per cent., while with coal, sixty per cent. may be taken as a good figure. The great difference in the efficiencies is due to the fact that fluid fuels require for combustion very little air above the theoretical quantity, while with the

solid fuels, fully twice the theoretical quantity must be admitted to dilute the products of combustion.

Correcting our previous results for these efficiencies, we have:

POUNDS OF WATER ACTUALLY EVAPORATED FROM 212° F., PER POUND OF FUEL.

Anthracite,	9.
Bituminous,	8.8
Petroleum,	18.9
Coal Gas,	18.8
Generator Gas,	2.9
Water Gas,	7.8

These figures agree closely with the results of experiments.

We will now consider the subject of cost.

The following cities have been selected, as manufacturing centres, termini of railroads, or fuelling ports for steamers.

In the case of petroleum, as it is rarely shipped in the crude state, an approximation is made by adding to the cost at the nearest shipping port, the freight charged on refined petroleum, and ten per cent. to cover duties and other charges.

Owing to the difficulty of obtaining prices in some of the cities, there may be some errors.

COSTS. MARCH, 1884.

	Anthracite per ton of 2,240 lbs.	Bituminous per ton of 2,240 lbs.	Coal gas per 1,000 cub. ft.	Generator gas per 1,000 cub. ft.	Crude petroleum per bbl. of 42 gal.	Water gas per 1,000 cub. ft.
New York,	$4 00	$4 25	$1 75	$0 45	$1 80	$0 50
Chicago,	5 00	3 50	1 25	0 45	2 00	0 50
New Orleans,	6 00	3 50	3 00	0 45	2 50	0 50
San Francisco,	12 00	7 50	3 00	0 55	2 00	0 60
London,	5 00	3 00	0 75	0 43	2 70	0 45
Port Natal,	12 50	11 00		Approximation.	4 00	Approximation.
Sydney,	12 00	7 00			4 50	
Valparaiso,	11 50	7 50			3 00	

In calculating the following table the specific gravity of coal gas is taken at .4; generator gas, at .44; water gas, at .48; petroleum, .8.

LBS. OF FUEL FOR $1.00. MARCH, 1884.

	Anthracite.	Bituminous.	Petroleum.	Coal gas.	Water gas.	Generator gas.
New York, ...	560	527	156	18	74	76
Chicago, ...	448	640	142	24	74	76
New Orleans, . . .	374	640	114	10	74	76
San Francisco, . .	187	299	142	10	62	62
London, ...	448	747	104	40	82	79
Port Natal, ...	179	204	71			
Sydney, ...	187	320	63		Approximate.	Approximate.
Valparaiso, ...	195	299	94			

These figures, multiplied by the actual evaporative powers as calculated, give:

LBS. OF WATER EVAPORATED FROM 212° F. FOR $1.00.

	Anthracite.	Bituminous.	Petroleum.	Coal gas.	Generator gas.	Water gas.
New York, ...	5040	4643	2948	338	220	577
Chicago, ...	4032	5638	2684	451	220	577
New Orleans, . . .	3366	5638	2155	188	220	577
San Francisco, . .	1683	2634	2684	188	179	484
London, ...	4032	6581	1966	751	228	640
Port Natal, ...	1611	1797	1342			
Sydney, ...	1683	2819	1191		Approximate.	Approximate.
Valparaiso, ...	1755	2634	1776			

RELATIVE COSTS.

New York, ...	$1 00	$1 08	$1 71	$14 92	$22 90	$8 70
Chicago, ...	1 00	0 71	1 50	8 72	18 30	7 00
New Orleans, . . .	1 00	0 59	1 56	17 90	15 30	5 80
San Francisco, . .	1 00	0 64	1 50	8 75	9 40	3 50
London, ...	1 00	0 61	2 05	7 16	17 70	6 30
Port Natal, ...	1 00	0 90	1 21			
Sydney, ...	1 00	0 34	1 39			
Valparaiso, ...	1 00	0 44	1 03			

These figures are very much against the fluid fuels, but there may be circumstances in which the benefits to be derived from their use will exceed the additional cost. It is difficult to make a comparison without considering particular cases, but for intermittent heating, petroleum would probably be more economical, though for a steady fire, coal holds its own.

XIII.

REPAIRS TO THE PHILADELPHIA TRACTION COMPANY'S CONDUIT.

By Prof. L. M. Haupt, Member of the Club.

Read (by Title) June 20th, 1885.

Although the defects of the conduit, which became manifest on the attempts made to operate the cables, were fully described in the daily papers of February and March last, there has been, I believe, no official reference to them in the Club, and as it is a matter of considerable interest in connection with the problem of local transit, I think it important that some record thereof should be found in our Proceedings.

I have therefore essayed to compile such a description from the material available, prefacing it, however, by a few general remarks on the subject of the requirements of cable conduits and the general principles of their construction.

The General Problem of Locomotion on Tramways.

First.—With reference to the power to be employed. It may be movable, or stationary; animal or mechanical.

- Power.
  - Animal, Quadrupeds.
  - or
  - Mechanical Motors.
    - Movable.
    - Stationary.
      - Steam.
      - Compressed air.
      - Electricity.

Upon the character of the power will depend many minor details. In the case under consideration the motor is steam applied by means of a stationary engine and transmitted to the car at any part of its route by a flexible conveyor or cable. This conveyor or belt may run upon sheaves placed on the surface of the ground as on the ordinary inclined planes, or encased in tubes or conduits beneath the surface where other considerations render it necessary. In the latter case the connection between the *cable* and car must be made through an open slot in some part of the conduit.

If the conveyor, however, be a fluid, as air, water, oil or electricity, carried by pipes or wires, and actuating one or more pistons either by pressure or vacuum, the conduit must be closed by a continuous valve, operated by the grip-bar attached to the passing car, or by an electric or magnetic current.

The Philadelphia Traction Company have selected for their motor a stationary steam engine and for their transmittor a wire cable $1\frac{1}{4}$ in. in diameter, sunk below the surface of the street pavements and protected by an iron conduit of peculiar form and construction.

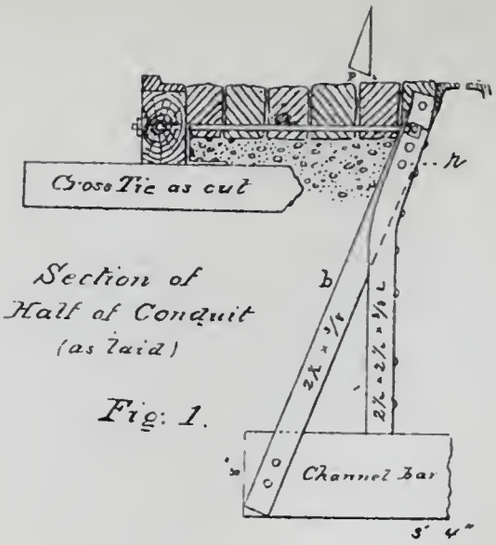
The Requirements of the Conduit

Are, 1st *freedom of motion* for the cable; 2d *provision for connecting* car and cable; 3d *means for preserving a constant gauge;* 4th *sufficient rigidity to resist displacement* of the system by water, frost, travel or other forces; 5th *facility of access* at frequent intervals; 6th *facilities for cleansing* (sanitary arrangements); 7th *durability and economy of construction.*

The problem then is to satisfy these various conditions in the most economical manner and still produce a system which shall always be operative. In the attempt made to solve it in this city, economy appears to have been the first instead of the last consideration, and some of the essential requirements seem to have been almost entirely ignored. Fig. 1 represents one-half of the tube in vertical section, showing the tie cut so as to permit the insertion of the conduit. The small iron rod *a* connecting the stringer *S* with the flange of the tube was intended to maintain the opening in the slot by its tension on the stringer. The tie having been cut becomes simply a block resting on a compressible soil, readily affected by all the forces to which it may be subjected.

Such was the arrangement at a point where a movement of only a quarter of an inch would render useless the entire plant.

From the *form* given to the top of the conduit it will also be seen that as it is inclined to the vertical, there will be a component of the passing loads which will press directly upon its surface and operate to close the slot. See *P*, Fig. 1. This force will be about .3 of the load, whatever it may be. It is thus seen



Section of Half of Conduit (as laid)

Fig: 1.

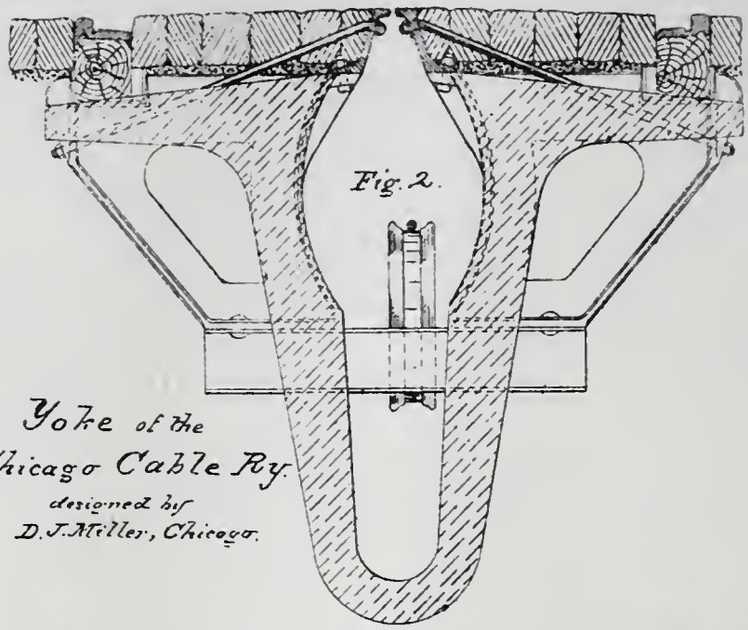


Fig. 2.

Yoke of the Chicago Cable Ry. designed by D. J. Miller, Chicago.

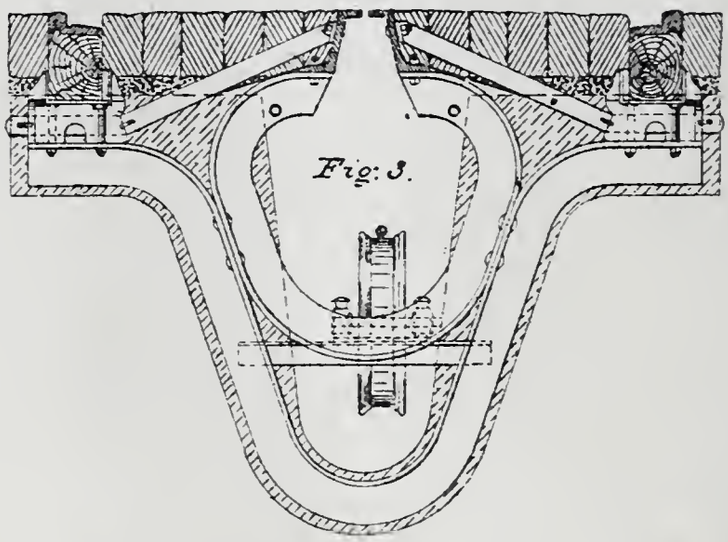


Fig: 3.

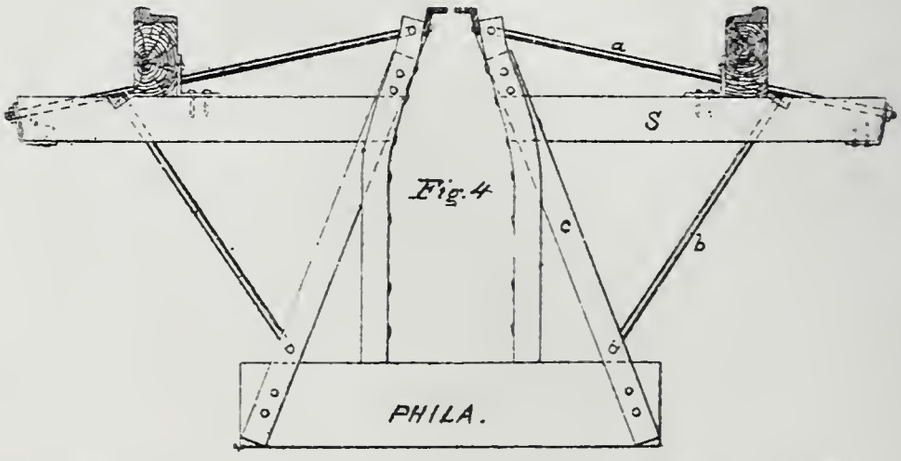


Fig. 4

SCALE. 9" 6" 3" 0 1 2 3 4 5 Ft.

that the combined forces of frost, pressure from pavement and earth filling and weight of travel, all of which tend to close the slot, were resisted only by the stiffness of a plate iron flange connected by a light rod to a wooden system, in itself movable. The bar *b* is of little use above the rivet *r* to resist these forces, as it lies in the plane of the upper face of the conduit and consequently cannot aid by a direct pull, but merely by its resistance to flexure, acting as a cantilever about an axis through *r*.

The requirements, Nos. 2, 3 and 4, are therefore so inadequately provided for as to have been found useless in practice. In fact the slot may readily be diminished $\frac{1}{16}$ of an inch by a slight pressure of the hand on the side of the conduit. The same experiences in San Francisco and Chicago led to the more substantial cast and wrought iron yokes, embedded in concrete, as seen in Figs. 2 and 3, and which have been found to answer every purpose, resisting the severe cold of 20° below zero successfully.

The remedy proposed, if the press reports are correct, consisted simply of a horizontal strut *S*, Fig. 4, abutting against the side of the tube at the angle and the tie *a*, passing through a hole in the stringer to the outer end of this strut where it bears on a cast angle block. The rod *b* was not introduced. This system would have proved insufficient, as it was merely hung upon the side of the tube and resisted only by its weight in addition to that of the earth and pavement over it. By introducing the tie *b* the side of the conduit has been made a trussed girder and is well braced by the two triangles so formed. The lower end of *b*, instead of being connected with the brace *c*, which is drilled to receive it, should have been attached to the channel bar, or the angle iron of the tube.

The arrangement of Fig. 4 is doubtless the cheapest and most effective that could have been substituted. It was claimed at the outset that the repairs would cost but $500 per mile. A rough estimate would bring it to about $15,000 per mile, which is probably considerably below cost.

The mechanical and sanitary details, the benefits to the traveling public, and the rates of fare, are all questions which there is not now time to dwell upon, but the following clippings from *The Press*, of March 18th, 1885, and the *New York Herald*, of July

13th, 1885, will give much additional information of value, by those competent to know.

"The engineers of the Philadelphia Traction Company have discovered that in the construction of the cable roads on the West Philadelphia and Columbia Avenue lines and their various branches, several serious mistakes were made that must be rectified before the lines can be made a permanent success. It is said that the road has already cost between $40,000 and $50,000 per mile for the twelve miles of road laid, and one of the engineers is authority for the statement that an additional expenditure of about $250,000 will be required to correct the blunders in design and construction. A gang of nearly a hundred men was at work yesterday on the north side of the city buildings. They were the pioneers in a task of immense proportions. They cut out the carefully laid pavement between the street car tracks, dug down to a depth of nearly two feet, inserted brand new wooden ties beneath the stringers and altered the entire system of iron braces by which the cable conduits are held in place. Before this task of reconstruction is completed, the same work must be done throughout the entire system, an aggregate of about twelve miles of track and conduits, including the Columbia and West Philadelphia branches of the road.

The Indications of Failure.

Early in the winter, when several trial trips were made on Columbia Avenue, the system was found to work smoothly in mild weather. But a cold wave came, and the first day after that the slot through which the grip passes was found to have contracted at many points enough to retard the passage of the car. One cold night the grip of one of the cable cars became hopelessly jammed in the slot, and a score or more cars on Columbia Avenue were delayed. Since then no cars have been run by means of the cable.

The difficulty was easily explained, but not so easily rectified. The ground of the road-bed, more or less saturated with moisture, had suddenly become frozen. Expansion naturally ensued, and a terrific pressure was brought to bear on the sides of the iron conduits. As no adequate means had been provided to counteract this pressure, the slot in the top was considerably narrowed by the lateral pressure. Superficial efforts were made to keep the slots open by means of steel wedges, but in many instances the pressure broke them.

The mistakes made and the reconstruction necessary to rectify them are best explained in the words of one of the engineers now engaged upon a portion of the system, who talked freely of the matter yesterday.

"When the conduits were laid," said the engineer, "the ties that support the stringers on which the rails are laid were simply cut through and their ends left sticking out (as is indicated in the upper part of Fig. 1), which represents a cross-section of the conduit, showing the stringers and one of the cut ties. Of course, the cutting of these ties severed the only brace that kept the track gauge at its proper width, as the old ends of the ties became simply blocks for the stringers to rest on.

Faults in Construction.

"The braces substituted were small iron rods that were bolted on the outside of the stringers and fastened to the sides of the conduits just below the slot. These thin

rods were expected to do the double duty of keeping the track gauge right and resisting the pressure that tends to close the slot. It is easy to see that they were incapable of doing either, since the old fragments of the ties, being simply buried sticks of wood, were crowded back or forward with every contraction or expansion of the ground. Not only has this resulted in partially closing the slot, but in many places the gauge of the track—that is the width between the rails—has been considerably changed and the rolling stock has suffered in consequence.

"It is a fact not commonly known—and perhaps the officers of the company would not care to have it known—that since the conduits were laid no less than fifty axles have been broken under the horse cars running over the traction system. This has been caused by the strain due to the accidental narrowing of the gauge. Of course, the ties ought never to have been cut off in that rough manner, and the bracing rods ought not to have been bolted to the stringers at all.

The Proposed Changes.

"The changes that are about to be made are as follows: The old ends of the ties must be replaced by stout new ties, such as *S* indicates. The inner end of each tie is being cut so as to fit tightly against the side of the conduit. The outer end, extending beyond the line of the rail and stringer, is fitted with an iron shoe. New iron rods, nearly twice as thick as the old ones, connect the conduit, not with the stringer, but with the iron shoe bolted to the end of the tie itself, the stringers being bored so as to permit the passage of the rods through them. By this plan, it is believed, the ground pressure can be successfully resisted, and so long as the nuts on the rod bolts are kept screwed up tight the slot will probably remain open its proper width.

"These new ties and rods are being inserted on both sides of the conduit and at a distance of four feet apart. When it comes to making these changes along some twelve miles of track, therefore, you can get some idea of the magnitude of the undertaking. The work, however, need not necessarily prevent traffic over the road, and during the mild weather the company may even be able to use the cable while these alterations are in progress. Whether or not they will accomplish the purpose thoroughly can only be learned by experience.

"I think another mistake was made in using thin plate iron in the construction of the conduits. In the Philadelphia system the slot is formed simply by two common angle irons laterally bolted to the sides of the conduit, as is shown in Fig. 4. The conduits are made of plate iron only about one-eighth of an inch thick, and the angle irons of the slot are about the same thickness. Every heavy wheel, every stroke of a horse's hoof upon those weak angle irons is liable to warp them or crush them downward, in the absence of sufficient support beneath. People say: 'Has not this system been a complete success in Chicago and elsewhere?' Most people do not know that the Chicago system and the one now being built in New York are constructed upon a wholly different plan. In the systems of those cities heavy iron castings, the full width of the gauge, are inserted at every eight feet of the road. These castings not only form the orifice through which the cable runs and the slot through which the grip passes, but they form the support upon which the rails rest. It is impossible therefore that either the rails or the slot should spread or be crowded together. The slot is constructed upon a wholly different principle, as is shown in Fig. 2 or 3."

"Instead of thin angle irons the slot is flanked by heavy pieces of steel that rise

toward the street surface six inches from the castings on which they rest. The bolts, instead of being inserted laterally, are perpendicular, so that the strain from above comes directly upon the heavy castings, and not upon a set of small rivets bolted through the sides of thin plate iron conduits. Another difficulty, apparently unforeseen by the designers of the Philadelphia system, is the liability of injury to horses' feet. I understand that quite a number of valuable animals have had their hoofs injured by catching the calks of the shoe in the slot of the conduit.

"Another change that has been found necessary is in the construction of the boxes or manholes that are placed at intervals along the road to enable the workmen to gain access to the cable and pulleys. There are in all, I believe, between 500 and 600 of these already down. Like the other portions of the line these boxes were made of thin plate iron capped by a light iron lid, and they are already found to be too weak to withstand the wear and tear of the street traffic. They are becoming bent and crushed by the pounding from above and the pressure of the ground in expanding. To rectify this, castings are now being made which will be inserted in each of these boxes or manholes. The lid is heavier than that now used, and it rests upon strong supports at each corner which run down all the way to the bottom level of the conduits, and thus bring the pressure upon the ground, where it ought to be.

"Having given my whole time for months," the engineer concluded, "to the work of the work of the Traction Company, I am tolerably familiar with the defects as well as the strong points of the system, and however much the officers of the company may desire to keep these defects quiet, I believe the public have a right to know that they exist, and that the correction of them is going to be an expensive matter. In my opinion, the work of reconstructing the ties and braces, with the incidental tearing up and repaving of the streets, and the cost of replacing the boxes or manholes, will involve an expenditure of $250,000."—*From the Press of March 18th*, 1885.

The following is the report, in part, of an interview with an officer of the company—a synopsis of which was published in *The Star* of July 14th.

"All difficulties in the working of the traction road have been with the men," said P. A. B. Widener at his office on Walnut Street yesterday. "The mechanism is as nearly perfect as machinery can be, and, with the improvements which we have added, ours is unquestionably the best plant of the kind in this country. We have had a few accidents, of course, and some delays, but they are incident to operating new machinery with men only partially instructed as to its management. It speaks well for our employés, however, that up to this hour not a person has been injured. Doubts of its practicability are all dispelled, and the success which we confidently foresaw before we began to dig a trench is now assured. As soon as we have thoroughly equipped the two lines now finished, we shall go ahead to adapt the cable system to every main line we control in the city. Our entire railroad system of cars covers 180 miles of streets, and our receipts are fifty per cent. of all the fares in Philadelphia."

* * * * * * * * * * * * * * *

How the Road is Built.

"I have neglected to ask you about the structural details and the rolling stock?"

"In a trench, 30 in. deep, the wrought iron conduits are placed. The spaces at the sides are filled with concrete. This conduit is open on the upper edge, and the slot is located midway between the rails at all points, except where switches are in use. Each section of this tube is 16 ft. long, and every 32 ft. there is a wheel. The rope is of best Roebling steel, 1¼ in. in diameter, and is guaranteed for two years. Its tensile strength can hardly be estimated, but it is sufficient to draw a continuous line of loaded cars. The traction cars are forty per cent. larger, and are managed by a gripman and a conductor. One fact, proving the correctness of the theory, as well as the efficiency of the practice, is that the cable works just as well on a curve as on a straight line. The cars turn ordinary curves at exactly the same speed that they maintain at other points. The auxiliary rope from Second Street to Front, already spoken of, runs 3½ miles per hour, that from Twentieth to Second at 7 miles per hour and that from Twentieth to Forty-second at 9 miles per hour."

Helps Property Values.

"What is the effect on property along cable roads?" was asked.

"We hardly know yet, but we have every reason to expect that prices will be improved," replied Mr. Widener. "Captain Cole, of the Alaska Commercial Company, who is sitting in the outer office, declares that in San Francisco property along the cable road advanced 100 per cent. To maintain a cable road you must have a certain amount of business in order to be self-supporting. It costs as much to run the cable for half a dozen cars as for half a hundred. Small roads, or feeders to the main line, are more cheaply run by horses. We are prepared to start three new subordinate roads. The one great feature, beyond those of speed and economy, that renders the cable road so effective, is that it can fully accommodate the extraordinary requirements for transportation during the crowded hours of the morning and afternoon. This no horse railroad can ever possibly do."

The following additional clippings from the press will be of interest, as showing how the projected motor is working at present in this city.

"Street car riding on Market Street was accompanied with considerable risk yesterday, provided the passenger wanted to keep an engagement. If he pinned his faith to any one car it might get him there on schedule time or it might get him there in four hours. Blocks occurred at intervals throughout the day, the most serious point of obstruction being at Ninth Street.

Between 6.30 and 7 o'clock last evening four blocks occurred at this point, and shortly after 7 o'clock the cable was stopped and the cars were run to West Philadelphia by horse-power.

The cars were also blocked several times during the day and early evening at Eighth Street and other points. It was necessary all day long to keep men and horses stationed at short distances along the route to aid in keeping the procession of cars in motion. President Widener and the superintendent of the company directed matters along the route in person until 7 o'clock, when Mr. Widener drove away in

his carriage. Shortly afterwards the cable stopped, when the superintendent ordered several horse cars to jump the track and transfer their animals to the grip cars. The superintendent then also drove away.

Cars Along the Curb.

At 7.30 o'clock the tracks were clear, but a number of street cars were standing along the curb between Seventh and Tenth Streets. The principal blame for the numerous mishaps is shouldered on the ignorant drivers. It is alleged that by their carelessness or ignorance the grips run foul of the wheels supporting the cable at the junction at Ninth and Market Streets. Inquiry at the depot on Market Street, above Nineteenth, where the engines that operate the cable are located, elicited the information that a mishap had happened to the engine and that the cable would not be in operation again until this morning.

One employé said that some of the cogs on the big wheel had broken, but another said that a rod which had been used temporarily while a new one was being manufactured had broken and that it would be replaced this morning. The horse cars ran regularly throughout the evening. In West Philadelphia the blockades were quite as serious as those in the city. They occurred at intervals throughout the day, and at various points from the bridge to Forty-first Street. The greatest difficulty, however, was met with in the neighborhood of Thirty-third Street. In the morning an accident happened that almost resulted in a catastrophe.

Fast to the Cable.

One of the cable cars was approaching Thirty-third Street and the driver attempted to release the grip and bring the car to a stop. The lever refused to work, however, and the car dashed by the transfer station and up the hill that begins at this point. The conductor rang his bell repeatedly and the passengers shouted to the driver to stop. In the meantime the driver was tugging frantically at the lever, but it refused to relinquish its grip on the cable. The driver finally gave up his efforts to free the grip and devoted his attention towards warning pedestrians and wagons of the approach of the car by pulling away at the gong.

A ruminative mule ambled towards the track at Thirty-eighth Street. The gong clanged furiously and the driver shouted, but the mule was absorbed in reflection and paid no attention. The car struck him abaft the middle and rolled him gently over on his side. The car rattled on towards Forty-second Street, where a procession of cars were standing in line. The run-away car crashed into the last one in the line, the grip was broken and the runaway came to a standstill. The platforms of both cars were demolished, and they were taken to the repair shops. The driver and passengers escaped injury by jumping from the car. During the day three or four grips were broken, but no other accidents occurred. There was a great deal of grumbling among the regular patrons of the Market Street line, and there was quite an increase in the receipts of the Chestnut and Walnut Streets branch of the Traction Company."—*From the Times of July* 16th, 1885.

"It was announced yesterday that the cable motor cars would not be run upon Market Street for the next four or five days, as certain changes were to be made by the chief engineer and his assistants. To make the running of the cable as noiseless as possible the cogs of the wheels were made of wood, but as these cogs are wearing out, iron ones are to be substituted for them.

Officials of the Traction Company say that when this change in the cogs is made no more trouble is expected, except that which may arise from the inexperience of the 'grip' men. It is claimed that the delays and other annoyances that have been experienced by the company have been slight in comparison with those met with in Chicago when the cable road there was in its infancy."—*The Public Ledger, July 17th*, 1885.

"Annesly G. Shockley, colored, 16 years old, residing at 1633 Darien Street, was run over and had both legs broken by Cable Car No. 146 of the Union Line, at Eighth and Columbia Avenue, last evening."—*Public Ledger, January, 9th*, 1885.

This was the day of the trial on Columbia Avenue, when the cars were to have begun their regular trips, and it was found the slot was closed in places.

"The cable cars resumed their trips on Market Street yesterday in full numbers, but many vexatious delays occurred, charged chiefly to the inexperienced gripmen. At four o'clock in the afternoon a block occurred west of Broad Street, delaying the cars fully an hour. An additional car was attached to some of the cable cars."—*Ledger of Wednesday, July 22d.*

"And at this date (Aug. 4th), cable is not in operation because of some remaining imperfections."

SCALES OF MAPS.

PROF. L. M. HAUPT, March 21st, 1885.

The *Scale* may be defined to be the ratio of the field or object to the plot or drawing—and may be expressed in the form of a fraction, obtained by dividing the second quantity by the first; thus, if F represent the field and P the plot, the ratio or scale would be $\frac{P}{F}$. The antecedent, the real tangible object to be represented, being the unit of comparison, is made the divisor or first quantity, whilst the variable

representation of that object, which may be made of any size sufficiently large to show the parts, is taken as the second quantity or consequent; as in a geometrical progression, where the ratio is the quotient of any consequent divided by its antecedent.

Thus if n represent the number of units of the Field corresponding to one unit of the Plot, the general formula becomes an equality of ratios, $\frac{P}{F} = \frac{1}{n}$ from which it follows that $F = Pn$ or $P = \frac{F}{n}$; in other words, *any length in the field is obtained by multiplying its homologous line of the plot by the denominator of the scale,* and *any line on the plot is obtained by dividing the corresponding field dimension by the denominator of the scale.*

The units must invariably be of the same denomination. By observing these suggestions no confusion can arise as to what is meant by the scale. Thus, 1 mile to the inch = 63360 inches to 1 inch, or $\frac{1}{63360}$. In general if a scale (A) be represented by $\frac{1}{N}$ and another (B) by $\frac{1}{S}$ the ratio of A to B will be $\frac{B}{A} = \frac{1}{S} \div \frac{1}{N} = \frac{N}{S}$, which may be a whole number or fraction. If $N = 2S$, then $\frac{B}{A} = 2$, or B is twice as large as A.

Again if we wish to make a new scale B any number of times a given scale A, as $p\,A$, we substitute this value for B in the above equation and obtain $S = \frac{N}{p}$, or in other words divide the denominator of the fraction expressing the given scale by the multiplier (whether whole or fractional) for the denominator of the new scale. Thus if $N = 63360$ and p be $\frac{1}{3}$, s will be 190080, and the scale B will $= \frac{1}{190080}$.

It should be remembered also that a *larger scale always*

means a magnified representation of the surface as compared with some other map, and not a greater number of linear units to the inch or a greater area of surface represented in a given square of the map. For instance, 6 miles to an inch is not greater but less than one mile to the inch, being but $\frac{1}{6}$ the size—that is, it would take a much smaller sheet of paper to represent a given area at 6 miles than at 1 mile to the inch.

The scales of maps expressed decimally are to be avoided as unintelligible, as *e. g.*, the number $.00020\frac{5}{6}$, a mixed vulgar and decimal fraction, means simply a scale of $\frac{1}{4800}$, or 4800 feet to 1 foot = 400 feet to 1 inch.

It is always desirable to use the largest scale for the field notes, and sub-multiples of these for the compiled sheets. So far as possible, the same scale should be used for all the parts of an extended survey, that the several sections may be united in a general map. Exceptions may be made in case of special features requiring more minute study.

To assist in determining rapidly the equivalent numbers of such variable standards of comparison as may be represented by a linear unit of the map, or the reciprocal extent of map covered by a unit of the standard, two tables have been prepared which will be found appended. To these have been added the number of acres to the square inch of map for the various scales given in the list. These will prove valuable in rapidly estimating contents—by counting the number of square inches on the map, or by the use of the planimeter.

Should a scale be sought which is not included in the table, its multiple or sub-multiple may be found, and the quantities taken from the table multiplied by this factor will give the required amount excepting in the area column. To find the number of acres, square the chains as given in that column and divide by ten.

Table of Map Equivalents showing the number of units of different

No.	Scale.	Miles to one inch.	Kilometers to one inch.	Chains to one inch.	Poles to one inch.
1.	$\frac{1}{7349760}$	116.	186.6821	9280.000	37120.00
2.	$\frac{1}{2090880}$	33.	53.1078	2640.000	10560.00
3.	$\frac{1}{1267200}$	20.	32.18663	1600.000	6400.00
4.	$\frac{1}{1200000}$	18.9393	30.4791	1515.151	6060.60
5.	$\frac{1}{1013760}$	16.	25.7492	1280.000	5120.00
6.	$\frac{1}{1000000}$	15.7828	25.3992	1262.624	5046.50
7.	$\frac{1}{823680}$	13.	20.9209	1040.000	4160.00
8.	$\frac{1}{811008}$	12.8000	20.5994	1024.000	4096.00
9.	$\frac{1}{760320}$	12.	19.3129	960.000	3840.00
10.	$\frac{1}{696960}$	11.	17.7023	880.000	3520.00
11.	$\frac{1}{633000}$	10.0221	16.1286	801.768	3207.07
12.	$\frac{1}{633600}$	10.	16.09329	800.000	3200.00
13.	$\frac{1}{600000}$	9.4696	15.2398	757.575	3030.30
14.	$\frac{1}{506880}$	8.	12.87456	640.000	2560.00
15.	$\frac{1}{500000}$	7.8914	12.6996	631.313	2525.25
16.	$\frac{1}{443520}$	7.	11.2651	560.000	2240.00
17.	$\frac{1}{400000}$	6.3131	10.1597	505.050	2020.20
18.	$\frac{1}{380160}$	6.	9.65587	480.000	1920.00
19.	$\frac{1}{375000}$	5.9185	9.5239	473.480	1893.92
20.	$\frac{1}{316800}$	5.	8.04664	400.000	1600.00
21.	$\frac{1}{300000}$	4 7348	7.61992	378.780	1515.15
22.	$\frac{1}{253440}$	4.	6.43732	320.000	1280.00
23.	$\frac{1}{240000}$	3.7878	6.09570	303.030	1212.12
24.	$\frac{1}{200000}$	3.15656	5.07985	252.525	1010.10
25.	$\frac{1}{190080}$	3.	4.82793	240.000	960.00
26.	$\frac{1}{160000}$	2.5252	4.0638	202.020	808.08
27.	$\frac{1}{150000}$	2.36742	3.80496	189.393	757.57
28.	$\frac{1}{126720}$	2.	3.21866	160.000	640.00
29.	$\frac{1}{120000}$	1.89393	3.05784	151.515	606.06
30.	$\frac{1}{100000}$	1.57828	2.53995	126.262	505.05
31.	$\frac{1}{80000}$	1.2626	2.0319	101.010	404.04
32.	$\frac{1}{79200}$	1.2500	2.01166	100.000	400.00
33.	$\frac{1}{76800}$	1.21212	1.9604	96.967	387.87
34.	$\frac{1}{63360}$	1.	1.6093	80.000	320.00
35.	$\frac{1}{60000}$	0.94696	1.52392	75.757	303.03

denominations corresponding to one inch of Map for various scales.

Meters to one inch.	Yards to one inch.	Feet to one inch.	No. of acres to the sq. in.	Where used.	No.
186682.18	204160.0	612480.0	. . . .	Map of U. S. .	1.
53107.86	58080.0	174240.0	. . . .	Map of Pa. . .	2.
32186.635	35200.0	105600.0	. . . .	U.S.C.S. . . ,	3.
30479.7	33333.3	100000.0	229567.	U.S.C.S. . . .	4.
25749.27	28160.0	84480.0	163840.	△ India . . .	5.
25399.2	27755.7	83333.3	159420.	U.S.C.S. . . .	6.
20920.9	22880.0	70640.	114555.	. . . . .	7.
20599.416	22528.0	67584.0	104845.	. . . . .	8.
19312.95	21120.0	63360.0	92160.	R. R. Va. . . .	9.
17702.3	19360.0	57080.0	74796.	. . . . .	10.
16128.6	17638.9	52916.6	64283.	U.S.C.S. . . .	11.
16093.29	17600.0	52800.0	64000.	U. S. Eng. . .	12.
15239.8	16666.6	50000.0	57392.	U.S.C.S. . . .	13.
12874.65	14080.0	42240.0	40960.	Eng. Ord. Sur. .	14.
12699.6	13888.8	41666.6	39855.	U.S.C.S. . . .	15.
11265.1	12320.0	36960.	31360.	. . . . .	16.
10159.7	11111.1	33333.3	25507.	U.S.C.S. . . .	17.
9655.87	10560.0	31680.0	23040.	Ludlow's Rep. .	18.
9523.9	10416.5	31250.0	22419.	U.S.C.S. . . .	19.
8046.64	8800.0	26400.0	16000.	Barnes' Pa. . .	20.
7619.9	8344.3	25000.0	14348.	U.S.C.S. . . .	21.
6437.333	7040.	21120.	10240.	. . . . .	22.
6095.7	6666.6	20000.0	9183.	U.S.C.S. . . .	23.
5079.8	5555.5	16666.6	6372.	U.S.C.S. . . .	24.
4827.93	5280.0	15840.0	5760.	Ludlow's Rep .	25.
4063.8	4444.4	13333.3	4448.5	U.S.C.S. . . .	26.
3804.9	4166.6	12500.0	3587.	U.S.C.S. . . .	27.
3218.66	3520.0	10560.0	2560.	Sherman's Mrch	28.
3057.8	3333.3	10000.0	2296.	U.S.C.S. . . .	29.
2539.9	2777.7	8333.3	1594.	U.S.C.S. . . .	30.
2031.9	2222.2	6666.6	1112.	U.S.C.S. . . .	31.
2011.7	2200.0	6600.0	1000.	. . . . .	32.
1960.5	2133.3	6400.0	940.	Geol. Sur. . .	33.
1609.3	1760.0	5280.0	640.0	Fremont . . .	34.
1523.9	1666.6	5000.0	573.7	U.S.C.S. . . .	35.

Table of Map Equivalents showing the number of units of different

No.	Scale.	Miles to one inch.	Kilometers to one inch.	Chains to one inch.	Poles to one inch.
36.	$\frac{1}{59400}$	0.9375	1.50874	75.000	300.0
37.	$\frac{1}{50000}$	0.78914	1.26996	63.131	252.52
38.	$\frac{1}{47520}$	0.7500	1.20696	60.00	240.00
39.	$\frac{1}{40000}$	0.63131	1.0159	50.500	202.02
40.	$\frac{1}{39600}$	0.6250	1.0058	50.000	200.0
41.	$\frac{1}{39370}$	0.62138	1.	49.710	198.88
42.	$\frac{1}{38400}$	0.6060	0.9752	48.484	193.93
43.	$\frac{1}{38016}$	0.6000	0.9656	47.925	191.70
44.	$\frac{1}{31680}$	0.5000	0.80465	40.00	160.00
45.	$\frac{1}{30000}$	0.47348	0.7619	37.878	151.48
46.	$\frac{1}{25344}$	0.4	0.64373	32.000	128.00
47.	$\frac{1}{25000}$	0.39457	0.63967	31.565	126.26
48.	$\frac{1}{23760}$	0.37500	0.60349	30.000	120.00
49.	$\frac{1}{21120}$	0.33333	0.53589	26.666	106.66
50.	$\frac{1}{20000}$	0.31565	0.50798	25.2525	101.01
51.	$\frac{1}{19880}$	0.31250	0.50290	25.000	100.
52.	$\frac{1}{19200}$	0.30303	0.48762	24.242	96.96
53.	$\frac{1}{18818}$	0.29700	0.47796	23.760	95.04
54.	$\frac{1}{15840}$	0.25000	0.40232	20.	80.
55.	$\frac{1}{15000}$	0.23674	0.38099	18.9393	75.75
56.	$\frac{1}{11800}$	0.18750	0.30174	15.	60.
57.	$\frac{1}{10000}$	0.1578	0.25417	12.626	50.505
58.	$\frac{1}{9900}$	0.15625	0.25100	12.500	50.
59.	$\frac{1}{9600}$	0.15151	0.24376	12.121	48.484
60.	$\frac{1}{7920}$	0.12500	0.20112	10.	40.
61.	$\frac{1}{7200}$	0.1136	0.18378	9.0909	36.363
62.	$\frac{1}{6000}$	0.09471	0.15285	7.5757	30.303
63.	$\frac{1}{5940}$	0.09375	0.15092	7.5000	30.
64.	$\frac{1}{5000}$	0.078913	0.12695	6.31313	25.252
65.	$\frac{1}{4950}$	0.078123	0.12582	6.250	25.
66.	$\frac{1}{4800}$	0.07575	0.121881	6.0606	24.242
67.	$\frac{1}{3960}$	0 06250	0.100561	5.	20.
68.	$\frac{1}{3600}$	0.05681	0.091391	4.5303	18.121
69.	$\frac{1}{3333}$	0.05261	0.08463	4.2060	16.824
70.	$\frac{1}{3168}$	0.05	0.080466	4.	16.

denominations corresponding to one inch of Map for various scales.

Meters to one inch.	Yards to one inch.	Feet to one inch.	No. of acres to the sq. in.	Where used.	No.
1508.73	1650.0	4950.0	562.5	. . . . .	**36.**
1269.9	1388.8	4166.6	398.53	U. S. C. S. . .	**37.**
1206.975	1320.	3960.	360.	. . . . .	**38.**
1015.9	1111.1	3333.3	255.05	U. S. C. S. . .	**39.**
1005.83	1100.0	3300.0	250.00	U. S. C. S. . .	**40.**
1000.0	1093.6	3280.8	247.00	. . . . .	**41.**
975.24	1066.6	3200.0	235.08	Geol. Surv. Pa.	**42.**
965.59	1054.3	3163.0	229.67	. . . . .	**43.**
804.650	880.	2640.	160.0	. . . . .	**44.**
761.9	833.3	2500.	143.48	U. S. C. S. . .	**45.**
643.728	704.0	2112.0	102.2	. . . . .	**46.**
639.673	694.4	2083.3	99.64	. . . . .	**47.**
603.487	660.0	1980.0	90.00	. . . . .	**48.**
535.897	586.6	1760.0	70.859	. . . . .	**49.**
507.98	555.5	1666.6	63.72	. . . . .	**50.**
502.906	550.0	1650.0	62.50	U. S. C. S. . .	**51.**
487.617	533.3	1600.0	58.767	. . . . .	**52.**
477.96	522.72	1568.1	56.45	U. S. C. S. . .	**53.**
402.325	440.	1320.	40.00	. . . . .	**54.**
380.99	416.66	1250.	35.87	U. S. C. S. . .	**55.**
301.744	330.	990.	22.475	. . . . .	**56.**
254.177	277.77	833.33	15.942	U. S. C. S. . .	**57.**
251.004	272.	825.	15.625	. . . . .	**58.**
243.763	266.66	800.	14.070	2d Geol.Sur. Pa.	**59.**
201.125	220.	660.	10.	. . . . .	**60.**
183.782	200.	600.	8.264+	. . . . .	**61.**
152.854	166.66	500.	5.739+	. . . . .	**62.**
150.924	165.	495.	5.625+	. . . . .	**63.**
126.950	138.888	416.66	3.985+	U. S. C. S. . .	**64.**
125.8238	134.166	412.50	3.906	. . . . .	**65.**
121.88175	133.333	400.	3.672	2d Geol.Sur. Pa.	**66.**
100.5625	110.	330.	2.5	. . . . .	**67.**
91.391	100.	300.	2.066+	. . . . .	**68.**
84.6334	92.592	277.7	1.7713+	U. S. C. S. . .	**69.**
80.0466	88.	264.	1.6	. . . . .	**70.**

Table of Map Equivalents showing the number of units of different

No.	Scale.	Miles to one inch.	Kilometers to one inch.	Chains to one inch.	Poles to one inch.
71.	$\frac{1}{3000}$	0.04734	0.07610	3.7787	15.151
72.	$\frac{1}{2970}$	0.04687	0.07541	3.75	15.
73.	$\frac{1}{2500}$	0.03945	0.06396	3.1565	12.626
74.	$\frac{1}{2400}$	0.03787	0.06098	3.0379	12.1515
75.	$\frac{1}{1980}$	0.03125	0.05029	2.5	10.
76.	$\frac{1}{1280}$	0.02020	0.032507	1.6016	6.406
77.	$\frac{1}{1250}$	0.019728	0.031697	1.5767	6.307
78.	$\frac{1}{1200}$	0.018939	0.030578	1.5151	6.060
79.	$\frac{1}{1080}$	0.017046	0.027520	1.3636	5.454
80.	$\frac{1}{1000}$	0.0157	0.0254	1.2626	5.0505
81.	$\frac{1}{960}$	0.01515	0.024376	1.2121	4.848
82.	$\frac{1}{840}$	0.013258	0.021399	1.06057	4.2420
83.	$\frac{1}{792}$	0.0125	0.02011	1.	4.
84.	$\frac{1}{720}$	0.01136	0.018378	0.9091	3.6363
85.	$\frac{1}{600}$	0.009471	0.015285	0.75757	3.0303
86.	$\frac{1}{500}$	0.0078913	0.012695	0.63131	2.5252
87.	$\frac{1}{480}$	0.007575	0.012188	0.60606	2.4242
88.	$\frac{1}{360}$	0.00568	0.009139	0.45303	1.8121
89.	$\frac{1}{300}$	0.004734	0.007610	0.37787	1.5151
90.	$\frac{1}{240}$	0.003787	0.006098	0.30379	1.2151
91.	$\frac{1}{198}$	0.003125	0.005029	0.25	1.
92.	$\frac{1}{120}$	0.001894	0.003057	0.15151	0.6060
93.	$\frac{1}{69}$	0.000947	0.001528	0.07575	0.3030
94.	$\frac{1}{39.37043}$	0.0006213	0.001	0.0497101	0.1988405
95.	$\frac{1}{36}$	0.000568	0.0009139	0.045303	0.181212
96.	$\frac{1}{12}$	0.0001894	0.0003057	0.015151	0.0606
97.	$\frac{1}{1}$	0.00001578	0.00002536	0.0012595	0.00505

denominations corresponding to one inch of Map for various scales.

Meters to one inch.	Yards to one inch.	Feet to one inch.	No. of acres to the sq. in.	Where used.	No.
76.1057	83.333	250.	1.434+	. . . . .	71.
75.4138	82.5	247.5	1.406+	. . . . .	72.
63.9673	69.444	208.33	.9963+	U. S. C. S.	73.
60.9811	66.666	200.	.9182+	U. S. C. S.	74.
50.2906	55.55	166.66	.6376+	. . . . .	75.
32.5079	35.555	106.66	.2611+	U. S. C. S.	76.
31.6973	34.7222	104.166	.2491+	U. S. C. S.	77.
30.578	33.3333	100.	.229+	U. S. C. S.	78.
27.520	30.	90.	.185+	. . . . .	79.
25.4177	27.777	83.333	.1594	. . . . .	80.
24.3763	26.666	80.	.146+	. . . . .	81.
21.4046	23.3333	70.	.112+	. . . . .	82.
20.1125	22.	66.	.100+	. . . . .	83.
18.3782	20.	60.	.0826+	. . . . .	84.
15.2854	16.666	50.	.0573+	. . . . .	85.
12.695	13.8888	41.666	.0398+	U. S. C. S.	86.
12.18817	13.3333	40.	.0367+	. . . . .	87.
9.1391	10.	30.	.0206+	. . . . .	88.
7.61057	8.3333	25.	.0143+	. . . . .	89.
6.09811	6.6666	20.	.0092+	. . . . .	90.
5.02906	5.555	16.666	.00637+	. . . . .	91.
3.0578	3.3333	10.	.00229+	U. S. C. S.	92.
1.52854	1.6666	5.	.00057+	. . . . .	93.
1.	1.0936	3.2809	.000247+	. . . . .	94.
0.91391	1.	3.	.000206+	. . . . .	95.
0.30578	0.3333	1.	.0000229+	. . . . .	96.
0.025368	0.02777	0.083	.000000158+	. . . . .	97.

A Reciprocal Table of Map Equivalents showing the number of inches of

No.	Scale.	1 Mile.	1 Kilometer.	1 Chain.	1 Pole.
1.	$\frac{1}{7\,349\,760}$	0.0086205	0.005359	0.00010775	0.00002693
2.	$\frac{1}{2\,090\,880}$	.03030	.01882	.000378	.0000945
3.	$\frac{1}{1\,267\,200}$	.05000	.03106	.000625	.00015625
4.	$\frac{1}{1\,200\,000}$	.05280	.03280	.000660	.0001650
5.	$\frac{1}{1\,013\,760}$	.06250	.03883	.000781	.00019525
6.	$\frac{1}{1\,000\,000}$	0.06336	0.03937	.000792	.00019800
7.	$\frac{1}{823\,680}$	.076923	.04780	.0009615	.0002404
8.	$\frac{1}{811\,008}$	.078125	.04854	.0009765	.0002441
9.	$\frac{1}{760\,320}$	.08333+	.05177	.001041	.00026025
10.	$\frac{1}{696\,960}$	.090909	.056490	.001136	.000284
11.	$\frac{1}{635\,000}$	0.09979	0.06199	.001247	.00031175
12.	$\frac{1}{633\,600}$	.10000	.06213	.001250	.0003125
13.	$\frac{1}{600\,000}$	.10560	.06561	.00132	.0003300
14.	$\frac{1}{506\,880}$	.12500	.07766	.001562	.0003905
15.	$\frac{1}{500\,000}$	.12672	.07874	.001584	.0003960
16.	$\frac{1}{443\,520}$	0.142857	0.089736	.001786	.000446
17.	$\frac{1}{400\,000}$	.15840	.09842	.00198	.0004950
18.	$\frac{1}{380\,160}$	.16666+	.10355	.002083	.00052075
19.	$\frac{1}{375\,000}$	.16896	.10498	.00211	.00052800
20.	$\frac{1}{316\,800}$	.20000	.12426	.002502	.0006250
21.	$\frac{1}{300\,000}$	0.21120	0.13122	.00264	.0006600
22.	$\frac{1}{253\,440}$	.250000	.155335	.003125	.0007812
23.	$\frac{1}{240\,000}$	.26400	.16403	.003300	.0008250
24.	$\frac{1}{200\,000}$	.31680	.19684	.003960	.0009900
25.	$\frac{1}{190\,080}$	.33333+	.20711	.004166	.0010415
26.	$\frac{1}{160\,000}$	0.39600	0.24605	.004950	.0012325
27.	$\frac{1}{150\,000}$	.42240	.26245	.005280	.0013200
28.	$\frac{1}{126\,720}$	.50000	.31067	.006250	.0015625
29.	$\frac{1}{120\,000}$	.52800	.32807	.006600	.0016500
30.	$\frac{1}{100\,000}$	.63360	.39368	.00792	.0019800
31.	$\frac{1}{80\,000}$	0.79200	0.49210	.009900	.0024750
32.	$\frac{1}{79\,200}$	.8	.49710	.01	.0025
33.	$\frac{1}{76\,800}$	.82500	.512611	.010312	.0025780
34.	$\frac{1}{63\,360}$	1.00000	.62130	.012500	.0031250
35.	$\frac{1}{60\,000}$	1.05600	.65614	.013200	.003300

Map and parts thereof, of the various scales now in use, which represent

1 Metre.	1 Yard.	1 Foot.	Where Used.	No.
.000005359	.00000489	.00000163	. . . . .	1.
.00001882	.0000172	.00000573+	Sherman's March . .	2.
.00003106	.0000284	.00000946+	Sherman's March . .	3.
.00003280	.0000300	.00001000	U. S. C. S.	4.
.00003883	.0000355	.00001183+	△ India	5.
.00003937	.00003600	.00001200	U. S. C. S.	6.
.0000478	.0000437	.0000145	. . . . .	7.
.00004854	.00004438	.00001479	. . . . .	8.
.00005177	.0000473	.00001576+	R. R. Va.	9.
.0000565	.0000516	.0000172	. . . . .	10.
.00006199	.0000566	.00001886+	U. S. C. S.	11.
.00006213	.0000568	.00001893	U. S. Eng's	12.
.00006561	.0000600	.0000200	U. S. C. S.	13.
.00007766	.0000710	.0000236+	Eng. Ord. Sur. . . .	14.
.00007874	.0000720	.0000240	U. S. C. S.	15.
.0000897	.0000811	.0000270	. . . . .	16.
.00009842	.0000900	.0000300	U. S. C. S.	17.
.00010355	.0000946	.00003153+	Ludlow's Rep. . . .	18.
.00010498	.0000960	.00003200	U. S. C. S.	19.
.00012426	.0001136	.00003753+	Barnes' Pa. Map, 1851	20.
.00013122	.0001200	.0000400	U. S. C. S.	21.
.0001553	.000142	.000047	. . . . .	22.
.00016403	.0001500	.0000500	U. S. C. S.	23.
.00019684	.000180	.0000600	U. S. C. S.	24.
.00020711	.0001893	.00006310	Ludlow	25.
.00024605	.0002250	.00007300	U. S. C. S.	26.
.00026245	.0002400	.0000880	U. S. C. S.	27.
.00031067	.0002840	.0000946+	Sherman's March . .	28.
.00032807	.0003000	.0001000	U. S. C. S.	29.
.00039368	.0003600	.0001200	U. S. C. S.	30.
.00049210	.0004500	.00015000	U. S. C. S.	31.
.0004971	.0004545	.00015151	. . . . .	32.
.00051261	.00046875	.00015625	Geol. Surv.	33.
.00062130	.00056800	.00018933+	Fremont	34.
.00065614	.000600	.000200	U. S. C. S.	35.

A Reciprocal Table of Map Equivalents showing the number of inches of

No.	Scale.	1 Mile.	1 Kilometer.	1 Chain.	1 Pole.
36.	$\frac{1}{59\ 400}$	1.066666	0.662801	.013333	.00333
37.	$\frac{1}{50\ 000}$	1.26720	.78737	.01585	.0039625
38.	$\frac{1}{47\ 520}$	1.333333	.82844	.016664	.0041660
39.	$\frac{1}{40\ 000}$	1.58400	.98421	.019800	.004950
40.	$\frac{1}{39\ 600}$	1.6	.994202	.02	.00500
41.	$\frac{1}{39\ 369}$	1.60934	1.00000	.020116	.0050290
42.	$\frac{1}{38\ 400}$	1.65000	1.02522	.020662	.00515550
43.	$\frac{1}{38\ 016}$	1.66666	1.03509	.0208333	.0052083
44.	$\frac{1}{31\ 680}$	2.000000	1.24260	.02500	.0062500
45.	$\frac{1}{30\ 000}$	2.11200	1.31228	.026400	.0066000
46.	$\frac{1}{25\ 344}$	2.50000	1.55334	.031250	.0078125
47.	$\frac{1}{25\ 000}$	2.53440	1.57474	.031680	.0079200
48.	$\frac{1}{23\ 760}$	2.66666+	1.65692	.03333+	.008333+
49.	$\frac{1}{21\ 120}$	3.00000	1.86403	.037500	.0093750
50.	$\frac{1}{20\ 000}$	3.16800	1.96842	.03960	.009900
51.	$\frac{1}{19\ 800}$	3.2	1.988404	.04	.010
52.	$\frac{1}{19\ 200}$	3.30000	2.05044	.04125	.0103125
53.	$\frac{1}{18\ 818}$	3.36698	2.09206	.042087	.0105275
54.	$\frac{1}{15\ 840}$	4.0	2.485507	.05	.0125
55.	$\frac{1}{15\ 000}$	4.22400	2.62456	.052800	.0132000
56.	$\frac{1}{11\ 880}$	5.33333	3.314009	.06666	.016666
57.	$\frac{1}{10\ 000}$	6.33600	3.93685	.079200	.0198000
58.	$\frac{1}{9\ 900}$	6.4	3.976808	.08	.020
59.	$\frac{1}{9\ 600}$	6.60000	4.10088	.082500	.020625
60.	$\frac{1}{7\ 920}$	8.	4.971014	.10	.025
61.	$\frac{1}{7\ 200}$	8.80000	5.46784	.11000	.027500
62.	$\frac{1}{6\ 000}$	10.56000	6.561423	.132000	.033000
63.	$\frac{1}{5\ 940}$	10.6666	6.628018	.133333	.03333
64.	$\frac{1}{5\ 000}$	12.67200	7.8737	.15840	.039600
65.	$\frac{1}{4\ 950}$	12.8	7.953616	.16	.04
66.	$\frac{1}{4\ 800}$	13.20000	8.201770	.165000	.041250
67.	$\frac{1}{3\ 960}$	16.	9.942028	.2	.05
68.	$\frac{1}{3\ 600}$	17.6	10.93568	.22	.055
69.	$\frac{1}{3\ 333}$	19.00990	11.81173	.237623	.05940575
70.	$\frac{1}{3\ 168}$	20.	12.42434	.25	.0625

Scale of Maps—Page L.

Map and parts thereof, of the various scales now in use, which represent

1 Metre.	1 Yard.	1 Foot.	Where Used.	No.
.000662	.00060606	.00020202	. . . . .	36.
.00078737	.000720	.0002400	U. S. C. S.	37.
.000828	.000857	.000286	. . . . .	38.
.00098421	.000900	.000300	U. S. C. S.	39.
.0009941	.0009090	.0003030	. . . . .	40.
.0010000	.0009144	.0003048	. . . . .	41.
.00102522	.0009375	.0003125	Geol.	42.
.001035	.000947	.0003156	. . . . .	43.
.0012426	.001136	.0003786	. . . . .	44.
.00131228	.0012000	.0004000	U. S. C. S.	45.
.00155334	.0014190	.0004730	. . . . .	46.
.00157474	.00144000	.0004800	. . . . .	47.
.00165692	.00151515	.00050505	. . . . .	48.
.00186403	.0017040	.0005680	. . . . .	49.
.00196842	.0018000	.0006060	. . . . .	50.
.001988	.001818	.0006060	. . . . .	51.
.00205044	.00187500	.0062500	. . . . .	52.
.00209206	.0019130	.0006376+	U. S. C. S.	53.
.002485	.002272	.0007575	. . . . .	54.
.00262456	.0024000	.0008000	U. S. C. S.	55.
.003314	.0030303	.0010101	. . . . .	56.
.00393685	.0036000	.0012000	U. S. C. S.	57.
.003976	.003636	.001212	. . . . .	58.
.00410088	.00375	.0012500	. . . . .	59.
.004970	.004544	.0015150	. . . . .	60.
.00546784	.005000	.001666+	. . . . .	61.
.006561423	.006000	.002000	. . . . .	62.
.006628	.0060606	.0020202	. . . . .	63.
.0078737	.007200	.002400	U. S. C. S.	64.
.007952	.007272	.002424	. . . . .	65.
.008201770	.0075000	.002500	. . . . .	66.
.00994	.009088	.003020	. . . . .	67.
.0109356	.01	.003999	. . . . .	68.
.01181173	.0108010	.003603+	U. S. C. S.	69.
.012424	.0113181	.0037727	. . . . .	70.

Scale of Maps—Page M.

A Reciprocal Table of Map Equivalents showing the number of inches of

No.	Scale.	1 Mile.	1 Kilometer.	1 Chain.	1 Pole.
71.	$\frac{1}{3\,000.}$	21.12	13.122846	.264	.066
72.	$\frac{1}{2\,970.}$	21.33333	13.256036	.26666	.06666
73.	$\frac{1}{2\,500}$	25.34400	15.74740	.31680	.079200
74.	$\frac{1}{2\,400}$	26.40000	16.40354	.330000	.082500
75.	$\frac{1}{1\,980}$	32.	19.88405	.4	.1
76.	$\frac{1}{1\,280.}$	49.50000	22.94414	.618750	.1546875
77.	$\frac{1}{1\,250.}$	50.68800	31.49480	.63360	.158400
78.	$\frac{1}{1\,200.}$	52.80000+	32.80708	.660000	.165000
79.	$\frac{1}{1\,000}$	63.36000	39.368538	.792000	.198000
80.	$\frac{1}{1\,080}$	58.66666	36.45231	.73333+	.18333+
81.	$\frac{1}{960}$	66.00000	41.00885	.825000	.206250
82.	$\frac{1}{840}$	75.42857	46.86726	.942857	.23571425
83.	$\frac{1}{789}$	80.30418	49.89670	1.003802	.2509505
84.	$\frac{1}{720}$	88.00000	54.67847	1.100000	.275000
85.	$\frac{1}{600}$	105.60000	65.61416	1.320000	.33000
86.	$\frac{1}{500}$	126.72000	78.73700	1.584000	.39600
87.	$\frac{1}{480}$	132.00000	82.01770	1.650000	.412500
88.	$\frac{1}{360}$	176.00000	109.35694	2.2000	.550000
89.	$\frac{1}{300}$	211.20000	131.22833	2.640000	.66000
90.	$\frac{1}{240}$	264.00000	164.03541	3.300000	.825000
91.	$\frac{1}{198}$	320.	198.8405	4.	1.
92.	$\frac{1}{120}$	528.00000	328.07083	6.600000	1.65000
93.	$\frac{1}{60}$	1056.00000	656.14166+	13.20000	3.3000
94.	$\frac{1}{39.3704}$	1609.330	1000.	20.11663	5.02916
95.	$\frac{1}{36}$	1760.	1083.5694	22.	5.5
96.	$\frac{1}{12}$	5280.00000	3280.7083	66.00000	16.5000
97.	$\frac{1}{1}$	63360.00000	39368.5000	792.0000	198.000

Map and parts thereof, of the various scales now in use, which represent

1 Metre.	1 Yard.	1 Foot.	Where Used.	No.
.0131288	.012	.004	. . . . .	71.
.013256	.0121212	.0040404	. . . . .	72.
.01574740	.014400	.0048000	U. S. C. S.	73.
.01640354	.015000	.005000	U. S. C. S.	74.
.0218712	.02	.007999	. . . . .	75.
.02294414	.0281250	.0093750	U. S. C. S.	76.
.03149480	.028800	.0096000	U. S. C. S.	77.
.03280708	.030000	.010000	U. S. C. S.	78.
.039368	.036000	.012000	. . . . .	79.
.03645231	.03333+	.0111111+	. . . . .	80.
.04100885	.037500	.012500	. . . . .	81.
.04686726	.0428547	.0142849	. . . . .	82.
.04989670	.0456273	.0152091	. . . . .	83.
.05467847	.050000	.016666+	. . . . .	84.
.06561416	.060000	.020000	. . . . .	85.
.07873700	.072000	.024000	U. S. C. S.	86.
.08201770	.075000	.025000	. . . . .	87.
.10935694	.100000	.033333+	. . . . .	88.
.13122833	.12000	.040000	. . . . .	89.
.16403541	.150000	.050000	. . . . .	90.
.218712	.2	.079999	. . . . .	91.
.32807083	.30000	.100000	U. S. C. S.	92.
.6561416+	.600000	.200000	. . . . .	93.
1.	.914392	.304464	. . . . .	94.
1.093569	1.	.333333	. . . . .	95.
3.2807083	3.00000	1.000000	. . . . .	96.
9.8421249	36.000	12.000	. . . . .	97.

A CO-ORDINATE METHOD OF ASCERTAINING DISTANCES IN RECTANGULAR CITIES.

John H. Dye, June 21st, 1884.

The following illustrates the method of ascertaining the distances (*via* the streets) between any street intersections in a rectangular street system, as applied to

PHILADELPHIA.

DISTANCES ON SOUTH SIDE OF MARKET STREET FROM WEST SIDE OF DELAWARE AVENUE,

House Nos. Begin.	TO WEST SIDE OF	Width of St.	Total Distance.	House Nos. Begin.	TO WEST SIDE OF	Width of St.	Total Distance.
. .	Delaware Ave . . .	50	0	3400	Thirty-fourth St . .	60	14307
100	Front St	60	325	3600	Thirty-sixth St . .	60	15067
200	Second St	50	776	3700	Thirty-seventh St .	60	15627
300	Third St	50	1326	3800	Thirty-eighth St . .	60	16157
400	Fourth St	50	1771	3900	Thirty-ninth St . .	60	16617
500	Fifth St	50	2226	4000	Fortieth St	60	17277
600	Sixth St	50	2672	4100	Forty-first St . . .	40	17899
700	Seventh St	50	3118	4200	Forty-second St . .	60	18443
800	Eighth St	50	3565	4300	Forty-third St . . .	60	19037
900	Ninth St	50	4010	4400	Forty-fourth St . .	60	19430
1000	Tenth St	50	4456	4500	Forty-fifth St . . .	60	19898
1100	Eleventh St	50	4902	4600	Forty-sixth St . . .	60	20450
1200	Twelfth St	50	5348	4700	Forty-seventh St .	60	21010
1300	Thirteenth St . . .	50	5794	4800	Forty-eighth St . .	80	21540
1400	Broad St	113	6435	4900	Forty-ninth St . . .	60	22050
1500	Fifteenth St	50	6881	5000	Fiftieth St	60	22610
1600	Sixteenth St	50	7327	5100	Fifty-first St	60	23170
1700	Seventeenth St . .	50	7773	5200	Fifty-second St . .	60	23730
1800	Eighteenth St . . .	50	8219	5300	Fifty-third St . . .	60	24290
1900	Nineteenth St . . .	50	8665	5400	Fifty-fourth St . . .	60	24800
2000	Twentieth St . . .	50	9111	5500	Fifty-fifth St	60	25454
2100	Twenty-first St . .	50	9656	5600	Fifty-sixth St . . .	60	26014
2200	Twenty-second St .	60	10112	5700	Fifty-seventh St . .	80	26574
2300	Twenty-third St . .	50	10435	5800	Fifty-eighth St . .	60	27114
. .	*Schuylkill River* .	. .	11360	5900	Fifty-ninth St . . .	60	27674
3000	Thirtieth St	60	12027	6000	Sixtieth St	60	28234
3100	Thirty-first St . . .	80	12573	6100	Sixty-first St	60	28794
3200	Thirty-second St . .	60	13060	6200	Sixty-second St . .	60	29354
3300	Thirty-third St .	60	13746	6300	Sixty-third St . . .	100	29954

NORTH OF MARKET ST.				SOUTH OF MARKET ST.			
Distances, on West Side of Broad St., from South Side of Market St.				Distances, on West Side of Broad St., from South Side of Market St.			
House Nos Begin.	TO NORTH SIDE OF	Width of St.	Total Distance.	House Nos. Begin.	TO SOUTH SIDE OF	Width of St.	Total Distance.
100	Arch St	66	830	100	Chestnut St	55	534
200	Race St	50	1496	200	Walnut St.	50	1094
300	Vine St	50	2178	. . .	Locust St	50	1514
400	Callowhill St . . .	70	2747	300	Spruce St	50	1964
. .	Pennsylvania Ave .	80	3019	400	Pine St	50	2487
. .	Hamilton St. . . .	50	3275	500	Lombard St	50	2819
500	Buttonwood St. . .	40	3494	600	South St.	51	3192
. .	Spring Garden St .	120	3821	700	Bainbridge St . . .	50	3512
600	Green St.	70	4289	800	Catharine St	50	4241
. .	Mount Vernon St .	50	4530	900	Christian St	66	4531
. .	Wallace St	50	4782	1000	Carpenter St	50	4882
700	Fairmount Ave . .	50	5480	1100	Washington Ave . .	100	5353
800	Brown St	50	5789	. . .	Ellsworth St	50	5738
. .	Parrish St.	50	6195	1200	Federal St.	50	6123
900	Poplar St	60	6650	1300	Wharton St	50	6695
1200	Girard Ave	80	7121	1400	Reed St	50	7145
1300	Thompson St . . .	50	7749	1500	Dickinson St. . . .	50	7595
1400	Master St	50	8217	1600	Tasker St	50	8045
1500	Jefferson St	50	8722	1700	Morris St	50	8595
1600	Oxford St	50	9247	1800	Moore St.	50	8945
1700	Columbia Ave . . .	60	9771	1900	Mifflin St	50	9395
1800	Montgomery Ave .	50	10331	2000	McKean St	50	9845
1900	Berks St.	50	10831	. . .	Passyunk Ave. . .	50	. . .
2000	Norris St	50	11431	2100	Snyder Ave	75	10307
2100	Diamond St. . . .	70	11981	2200	Jackson St.	60	10755
2200	Susquehanna Ave .	60	12571	2300	Wolf St	60	11215
2300	Dauphin St	50	13151	2400	Ritner St	60	11675
2400	York St	50	13701	2500	Porter St	60	12135
2500	Cumberland St . .	50	14251	2600	Shunk St	60	12595
2600	Huntingdon St. . .	50	14801	. . .	Moyamensing Ave .	60	12924
2700	Lehigh Ave	80	15401	2700	Oregon Ave	120	13115
2800	Somerset St	50	15971	2800	Johnston St	60	13575
2900	Cambria St	50	16521	2900	Bigler St	60	14035
3000	Indiana St	50	17071	3000	Pollock St.	60	14495
3100	Clearfield St . . .	50	17621	3100	Packer St	60	14955
3200	Allegheny Ave . .	120	18241	3200	Curtin St	60	15415
3300	Westmoreland St .	50	18791	4300	League Island. . .	. .	20444
3400	Ontario St.	50	19341				
3500	Tioga St.	50	19891				
3600	Venango St	50	20441				
3700	Erie Ave	120	21061				
. . .	Germantown Ave .	. . .	. . . . .				

EXAMPLE.—Wanted, the distance from Sixth and Dickinson Streets to Thirty-second and Market Streets.

Thirty-second Street = ... 13,060
Deduct Sixth Street = ... 2,672

From Sixth to Thirty-second, on Market Street = ... 10,388
Add Market to Dickinson Street = ... 7,595

Total from Sixth and Dickinson to Thirty-second and Market Streets = ... 17,983

A Co-ordinate Method of Ascertaining Distances—Page B.

RELATIVE COST OF HAULAGE, IN THE ANTHRACITE MINES OF PENNA., BY MULES AND LOCOMOTIVES.

A. W. Sheafer, November 1st, 1884.

Kalmia Colliery, Schuylkill Co., Pa.* Thickness of coal bed, 6′ to 10′. Tonnage, 1882, 201,000 tons.

Length of main gangway, about 3 miles, principally in straight line. Round trip, 6 miles. Three locomotives in constant use.

Locomotives, Baldwin inside connected, Class 4–10 C.

	One Locomotive.	Sixteen Mules.	Saving by Locomotive.
Time of trip,	1h. 40m.		
Haul of cars per trip, 2½ tons capacity each,	18 to 26		
Haul of cars per day,	133	133	
Average steam pressure,	105 lbs.		
Average expense per day.			
Coal, 1097 lbs	$1.35		
Oil, waste, packing, etc.,	.70		
Repairs and renewing (estim'd),	.60		
Wages, engineer and boy to switch, etc.,	3.33		
Feeding, shoeing, repairs to harness, depreciation and death, @ 83c. per day,		$13.28	
Drivers, one for 6 mules, @ $1.70 per day,		4.53	
Oil and cotton,		.40	
Total expense per day,	$5.98	$18.21	
Cost per car per 3 miles,	4.5c.	13.69c.	
" " " " mile,	1.5c.	4.56c.	3.06c.
" " ton, " "	.6c.	1.82c.	1.22c.
Per day,			$12.23

Use of mules also requires more cars (124 : 92), more turnouts, and more repairs to roads.

* These results were obtained from Thos. H. Phillips, Supt., and are based on the work of the year 1882.

THE BLUE PRINT PROCESS.

R. W. Jones, November 1st, 1884.

1. Cover a flat board, the size of the drawing to be copied, with two or three thicknesses of common blanket or its equivalent.

2. Upon this, place the prepared paper, sensitive side uppermost.

3. Press the tracing firmly and smoothly upon this paper, by means of a plate of clear glass, laid over both and clamped to the board.

4. Expose the whole—In a clear sunlight—from 4 to 6 minutes. In a winter's sun, from 6 to 10 minutes. In a clear sky, from 20 to 30 minutes.

5. Remove the prepared paper and pour clear water on it for one or two minutes, saturating it thoroughly, and hang up to dry.

The sensitive paper may be readily prepared, the only requisite quality in the *paper* itself, being its ability to stand washing.

Cover the surface evenly with the following solution, using such a brush as is generally employed for the letter-press: 1 part Soluble Citrate of Iron (or Citrate of Iron and Ammonia), 1 part Red Prussiate of Potash, and dissolve in *ten* parts of water.

The solution must be kept carefully protected from light, and better results are obtained by not mixing the ingredients until immediately required. After being coated with the solution, the paper must be laid away to dry in a dark place, and must be shielded entirely from light until used. When dry, the paper is of a yellow and bronze color. After exposure the surface becomes darker, with the lines of the tracing still darker. Upon washing, the characteristic Blue tint appears, with the lines of the tracing in vivid contrast. Excellent results have been obtained from glass negatives by this process.

REPRODUCTION OF DRAWINGS IN BLUE LINES ON WHITE GROUND.

A. H. Haig, November 15th, 1884.

The following process for making photographic copies of drawings in blue lines on white background, was invented by H. Pellet, and is based on the property of perchloride of iron of being converted into protochloride on exposure to light. Prussiate of potash when brought into contact with the perchloride of iron immediately turns the latter blue, but it does not affect the protochloride.

A bath is first prepared consisting of ten parts perchloride of iron, five parts oxalic or some other vegetable acid, and one hundred parts water. Should the paper to be used not be sufficiently sized, dextrine, gelatine, isinglass or some similar substance must be added to the solution. The paper is sensitized by dipping in this solution and then dried in the dark, and may be kept for some length of time. To take a copy of a drawing made on cloth or transparent paper, it is laid on a sheet of the sensitive paper and exposed to light in a printing frame or under a sheet of glass. The length of exposure varies with the state of the weather, from 15 to 30 seconds in summer, to from 40 to 70 seconds in winter, in full sunlight. In the shade, in clear weather, 2 to 6 minutes; and in cloudy weather, 15 to 40 minutes may be necessary. The printing may also be done by electric light. The print is now immersed in a bath consisting of 15 to 18 parts of prussiate of potash per 100 parts of water. Those parts protected from the light by the lines of the drawing immediately turn blue, while the rest of the paper where the coating has been converted into protochloride by the effects of light, will remain white. Next, the image is freely washed in water and then passed through a bath consisting of 8 to 10 parts of hydrochloric acid to 100 parts of water, for the purpose of removing protoxide of iron salt.

It is now again washed well in clean water and finally dried, when the drawing will appear in blue on a white background.

NOTES AND COMMUNICATIONS.

DESCRIPTION OF THE CONSTRUCTION AND MANNER OF TURNING OF THE LARGE HOISTING DRUMS OF THE CALUMET AND HECLA MINING CO.

Regular Meeting, January 24th, 1885.—Mr. Chas. T. Thompson presented the following: These drums, the construction and manner of turning which I am about to describe, were designed by Mr. E. D. Leavitt, Jr., of Cambridgeport, Massachusetts, for the Calumet and Hecla Mining Co., of Michigan, and were constructed by the I. P. Morris Co., of this city. They were three (3) in number (a fourth one having been made, but not turned, some time before and shipped to the mines to be there turned). They are 20 ft. 4½ in. diameter at the pitch line of rope, 8 ft. 3 in. wide on face of winding surface, and 10 ft. over all. They run loose on shafts of Nashua steel 15 in. diameter. Each is driven by a spur wheel 24 ft. diameter, keyed to the shaft, from which power is taken to the drum by a wrought iron friction belt. The rim of the drums is of cast iron and is in eight segments, held together by 18—1⅛ in. fitted bolts for each joint. The hub is of cast iron 9 ft. 9¼ in. long, and is made in two pieces, held together by 20—1½ in. reamed bolts, and 24—1¼ in. bolts. The hub has three sets of circular bosses cast on it, one at each end and one in the middle. These are so arranged that the radial stays (to which I will call your attention later), may pass through holes cored for them and receive nuts on each side for adjusting the length of the stays. The hub is lined with babbitt metal which extends over the ends, so that all moving parts have a wearing surface of the material.

One of the peculiarities of these drums is that they depend almost entirely on compression to retain their shape. The rim is held in its position to the hub by 48—2¼ in. stays which are fastened, as before described, to the hub. On account of the small diameter of the stays their use as struts is of little account, but the whole dependence must be placed on their tensile strength to keep the drum in its place.

There are besides 16—1½ in. stays, running diagonally from one edge of the drum to the opposite side of the hub for stiffness. These have turnbuckles to take up the strains. On one side of the rim, separated from the winding groove by a flange, there is a groove 18 in. wide and 3 in. deep. This is for wood packing, which is held in place by countersunk bolts, and upon this works the friction bands for hoisting, and the brake strap for lowering. The face of the drum, or winding surface, has a turned groove, or thread of 1⅝ in. pitch. This is turned for the rope to lie in.

On the opposite end of the drum from the friction groove is the hole in which to fasten the rope to the drum. This hole is placed at the end of the thread. Alongside of the drum, keyed fast to the shaft, is a spur wheel 24 ft. diameter, 58 in. face, 4.71 in. pitch, on one of the arms of which is placed a pair of hydraulic cylinders which are connected to a bell crank, to which is fastened the wrought iron friction belt, 8 in. wide by half an inch thick, which operates the drum. This works on wood. The brake for lowering and holding the drum is the same size as the friction belt, and is also worked by a pair of hydraulic cylinders and a bell crank, but these are placed on the platform.

There is but one piston rod to each pair of hydraulic cylinders for the friction belt and brake strap. The large cylinder is 7¾ in. diameter, and the the small one 4 in.

diameter. The larger is used to apply the friction, while the small one loosens it, and drives the large one back again to its former position. The manner of connecting the accumulator with these cylinders is very ingenious and deserves mention. Two holes are bored in the main shaft, one for each cylinder, and these are connected to the cylinders by pipes tapped into the shaft. On the end of the shaft is bolted a small brass casting, which has two holes cored in it, ending in separate outlets, one near the shaft and one farther away. On this casting slip two circular rings with a groove cut in each. These grooves match the outlets of each hole, and to these rings are joined the accumulators, so that the water has at all times a free access to the cylinders. These rings are packed on each side by a leather cup (of the ordinary style used for hydraulic packing), filled with hemp. These are set up by the use of screws.

The weight of the car for which this drum is intended, is 2 tons; weight of load, 2 tons; weight of rope, 2½ lbs. per foot; length of shaft, 4,000 ft.; incline, 39°; dead weight to be started by drum, 18,000 lbs.

The drum runs 20 revolutions a minute, giving a speed of skip of 1,280 ft. per minute. Total weight, 142,713 lbs.

Owing to the large size of these drums, the I. P. Morris Co. had to arrange some way to turn them, as their pit was not wide enough. The following plan was adopted: In the erecting shop two small foundations of brick were built. On these were placed two frames or standards of cast iron 8 ft. 6 in. high, 9 ft. wide at bottom, 5 ft. 6 in. wide at top, weighing 17,440 lbs. each; these were suitably braced to insure great stiffness. These were run up with sulphur to insure a good bearing on the foundations. On top of these were placed adjustable pedestals of Mr. E. D. Leavitt, Jr.'s type, and these were run with lead. From the frames cast iron girders were fastened, reaching to the wall of the building. On these girders another girder was placed to hold the lathe bed. The carriage on the lathe consisted of a long flat plate with suitable V grooves to fit the ways of the bed; several T slots were in the carriage to hold the tool carriage in place. There were two tools used at a time in all cases, except in the finishing cuts. The side motion or feed was carried to the lathe screw direct from the shaft of the drum by a series of bevel wheels and shafts. On the end of the lathe screw was placed a clutch to allow the throwing of the feed in or out at pleasure, also that in starting the cuts the carriage could be moved by hand.

The drum was driven by a small engine, with its own boiler, so as to be independent of the main boilers of the works. Power was taken from the engine by a belt to a small pulley, from thence, by a system of gearing, to the large spur wheel, before mentioned. This was fastened to the drum by means of wrought iron yokes. A piece of wood was used between the arm of the spur wheel and yoke on the driving side. The time required for turning and cutting thread was 200 hours. There were, as I have mentioned before, two tools used, one starting from the edge, and the other about the centre, so that the two would run out about the same time. One cut only was taken (except in case of last drum, where two were necessary) before commencing to cut the thread. The thread was a part of a circle and the edges were rounded off. The thread was first roughed out by a round nose tool, and when nearly to a proper size, a tool of the right shape was used to scrape out the thread. By this means was obtained threads with scarcely a perceptible chatter mark in them.

A LARGE LAND DREDGE.

Special Business Meeting, January 24th, 1885.—Mr. John C. Trautwine, Jr., exhibited and described drawings of a large Land Dredge built by the Osgood Dredge Co., of Albany, New York, for the Pacific Guano Co., to be used in removing 8 to 15 feet of material from the phosphate rock at Bull River, S. C.

The more prominent features of the machine are the car-body, the water tank, boiler and engine, the A frame, (so-called from its slight resemblance to the letter A,) the boom, the dipper-handle and the dipper, drawings of which were shown and described in detail.

Before the excavation is begun, the forward end of the car (the end nearest the dipper), is lifted clear of the track by means of 3 screw-jacks. When the machine has excavated as far in advance of itself as the length of the boom and that of the dipper-handle will permit, say about 8 feet, the car is again lowered to the track, the screw-jacks removed, and the car is moved forward about 8 feet by winding the rope upon the drum; the other end of the rope being attached to any suitable fixed object near the line of the track. The forward end of the car is then again lifted by means of the 3 screw-jacks and the digging is resumed. The machine cuts a channel from 25 to 35 feet wide, and deposits all the dirt upon one side. If necessary, it can dump earth about 25 feet above the track. The miners follow in the wake of the machine, getting out the phosphate as fast as it is uncovered. When the machine reaches the end of the field it is lowered to the track and the screw-jacks are removed. Shoes or skids are then placed upon the track and the wheels of the turntable are run up on them. This lifts the end wheels clear of the track, so that the car and machine rest entirely upon the turntable. By now blocking the turntable wheels and winding up only *one* of the ropes, the car body and the machine are swung around end for end. The digging is then resumed in the opposite direction, the temporary track, upon which the machine travels, being shifted to one side, so that the second channel is made alongside of the first. The earth removed in cutting this second channel is dumped into the first channel, the phosphate (as stated above) having been first removed.

The dipper is of plate steel and holds $1\frac{3}{4}$ cubic yards of earth when even full.

The machine is manned by an engineer, a fireman and a dipper-tender, besides which from five to ten laborers are required. These look after the track, etc.

THE ARTESIAN (?) WELLS OF NEW YORK CITY.

Special Business Meeting, January 24th, 1885.—The Secretary was enabled to present, through the courtesy of Samuel C. Perkins, Esquire, who had loaned it for the purpose, a description of the so-called Artesian Wells of New York City, embodied in a written report thereupon by Dr. Cyrus Edson, Chief Inspector of the Health Department. Of nine wells examined by Dr. Waller (the waters of eight of which were used, without treatment, in the manufacture of soda and mineral waters) all but one, which was pronounced "doubtful," are characterized as "bad and extremely dangerous for drinking purposes." All but one of the wells are under 70 ft. deep. The explanation of this pollution is given as follows:

"The strata composing the island, originally deposited in a horizontal position, have been thrown into folds, probably by the geological changes effected by the erup-

tion of the material now forming the Palisades (the trap—a solidified form of lava). After that the valley of the Hudson became the bed of an immense glacier, which ground off the top of the ridges, at the same time filling up the hollows with the boulders, sand and other detritus which it carried with it. The result is that our island consists of the upturned edges of the strata so worn off, and any water falling on the surface soaks in, guided by the trend of the strata, to make its appearance in a well (whenever such may be sunk) on the island. In other words, the water in any of the wells, however deep, is the drainage from the district closely adjacent to the spot where the well is sunk."

AN AUTOMATIC CAR COUPLER.

Regular Meeting, March 21st, 1885.—Mr. John Wood, Jr., visitor, exhibited handsome working models of cars, on tracks, equipped with the Curtis & Wood Automatic Car Coupler, and fully explained its workings. Various tests of the model were proposed and successfully made. The inventors claim that this coupler insures absolute safety in coupling and uncoupling cars, a great saving of links and pins, and much time in making up trains; that it can be applied to cars with little or no greater cost than the ordinary draw bar, which, in fact, is used, provided with an automatic steel hook instead of the ordinary pin, which hook has about double the strength of the pin now in general use; that it has all the advantages of the present link and pin coupler as to coupling to the ordinary draw-head or any other having a link or provided with a pin; that it can be applied to any freight car without changing the ordinary draft rigging, bolt or springs; that accuracy of coupling with the links in any possible position is assured by the construction of the bull-head throat, which guides the link when forced backwards to the proper position. When it is desired not to couple, the uncoupling lever (at outside end of end sills) is thrown up, thus placing the crank in an opposite position and making it impossible to couple.

THE OLD WERNWAG BRIDGE AT PHILADELPHIA.

Special Business Meeting, April 18th, 1885.

Philadelphia, *April 18th*, 1885.

Howard Murphy, Esq., *Secretary of the Engineers' Club of Philadelphia.*

Dear Sir:—I take pleasure in presenting to the Club in behalf of my father, Rich. B. Osborne, Civil Engineer, of this city, an engraving of Wernwag's Bridge, which he obtained in London years ago.

This structure was designed and built by Lewis Wernwag across the Schuylkill River at Fairmount. The corner-stone was laid with Masonic ceremonies April 28th, 1812. It was preceded by first a ferry and then a floating bridge, which was twice swept away by floods, in 1789 and 1810.

The Legislature chartered a company with a capital of $40,000 to build the Wernwag bridge, and to hold it for twenty-five years. It was a wooden structure, with the bottom member arched; 340 ft. span, 20 ft. rise; there were five trusses. The span was 98 ft. greater than any other in the world at that time. Each truss was an open built beam formed of a bottom curved solid built beam and of a single top beam,

which were connected by radial pieces, diagonal braces and inclined iron stays. The bottom curved beam was composed of three concentric solid built beams slightly separated from each other, each of which had seven courses of curved scantling in it, each course 6 in. thick by 13 in. in breadth; the courses, as well as the concentric beams, being firmly united by iron bolts, etc. A roadway that rested upon the bottom curved ribs was left on each side of the centre truss, and a footpath between each of the two exterior trusses.

The bridge was covered in by a roof and sheathing on the sides. Iron stays anchored the ends of the trusses to the abutments. On September 1st, 1838, a fire, supposed to have been of incendiary origin, destroyed this bridge, and no attempt was made to rebuild until 1839, when the City of Philadelphia appropriated $13,000 toward purchasing the rights, and the County Commissioners contracted with Charles Ellet, Jr., to erect a wire suspension bridge of his own design. This bridge, of 342 ft. span, was opened January 2d, 1842, and stood unimpaired for thirty years.

In 1874, the present double-decked iron bridge, designed by the Chief Engineer of the city, was built by the Keystone Bridge Company, of Pittsburg.

Yours truly,

PERCY T. OSBORNE.

SEWERAGE WORK AT ATLANTIC CITY, N. J.

SPECIAL BUSINESS MEETING, APRIL 18TH, 1885.—Mr. James F. Wood described the Sewerage Work now in progress at Atlantic City, N. J. The sewers are being laid, under contract, by Messrs. Robinson & Wallace, of New York, who expect to lay this year 600 ft. of 24-in. pipe, 1260 ft. of 20-in. and 4,000 ft. of 15-in. with their 6-in. connections. The above will drain into well 18 ft. deep by 24 ft. 6 ins. diameter; this well will be covered with two double floors 6 ft. apart and ventilated by brick stack 50 ft. high. The main sewer cuts the town in half, receiving the drainage from the long avenues on both sides. The sewage is expected to be pumped out and carried over the marsh, somewhere, and utilized. They are laying the pipes with fall of 7 ft. to the mile and propose to flush them with city water. In laying the pipes they have to sheet-pile both sides of the trench, which is 12 ft. deep in some places, the piling being put down by making quicksand with city water and dropping them in. They have 3-in. rabbit so as to make joint. Pipe joints under water are made with composition of North Carolina tar, linseed oil and lime; the piles, after filling up, are pulled out with derrick, capstan and old horse.

THE BEAUMONT ROCK DRILL.

SPECIAL BUSINESS MEETING, APRIL 18TH, 1885.—Mr. Jones Wister presented a description of the Beaumont Rock Drill, which is said to bore a 7 ft. 2-in. hole at the rate of from 42 to 120 ft. per week; to be suited to all rocks, but the very hardest, and to avoid the leakage and foul air incident to the use of dynamite. The workings of the drill were discussed by several members. Mr. John Fernie, M. Inst. C. E., who was present as the guest of the Club, at the request of the Secretary, described the character of the rock formation in which this drill had been used.

THE PURIFICATION OF SEWAGE.

Business Meeting, May 2d, 1885.—Mr. Kenneth Allen presented extracts from a paper by Henry J. Barnes, M.D., on Purification of Sewage by application to land, with especial reference to the City of Boston. Efficacy of system is endorsed by numerous authorities. Discharge into rivers found a failure in England and Prussia. In England there are 200 sewage farms. Dr. Frankland states that the sewage used never produced disease in the vicinity. At Women's Prison, Sherborn, Mass., Col. Waring employed five acres; sewage distributed by tile, with broken joints, 14 feet below surface, 5 feet apart; effluent taken by cross-sections of tile 5 feet below surface, and is clear and odorless. Analysis shows it to be unsatisfactory.

Utilization by agriculture and filtration proposed for Boston. A suitable soil will take 1 inch sewage per day with impunity. Gennevilliers farm cited, where effluent has fewer micro-organisms than the Seine on entering Paris. Frost no objection. In Dantzic it reaches 4 feet in depth, but effluent never falls below 37° F.

In the discussion following, Dr. H. P. Walcott said it must be remembered that at Gennevilliers the quantity of sewage used was optional with the farmer.

Dr. C. F. Falsom said the annual loss to the City of Boston would be from $20,000 to $50,000. In Paris, Dantzic and Berlin there is practically no alternative.

Elliot C. Clarke, C. E., mentioned Pullman as the only place claiming pecuniary profit from this method. House sewage only, amounting to 200,000 gallons daily, is disposed of. 1,500 acres, about two miles from town, are used. In 1883, but 150 acres were used. This is drained by pipes about 6 feet below surface. 10 acres are used as filter beds. After one season's application the sewage should be omitted one year.

Desmond Fitz-Gerald said "it would be a great waste of money to attempt any scheme of utilization at present."

THE BORUP COAL CHUTE.

Business Meeting, May 2d, 1885.—Mr. W. F. Newell, member of Civil Engineers' Society of St. Paul, introduced by Prof. Haupt, presented a description of the Borup Coal Chute, which is designed to prevent accidents to pedestrians in street openings, for convenience in receiving or removing material, and for ventilation of cellars and vaults. It consists of a cylindrical sheet-iron tube, open in front, to permit the dumping or throwing in of the coal. It is raised to about eighteen inches above the sidewalk, by means of two lugs cast on the under side of the lid, which fit and lock in openings cut in top of chute, to prevent the removal of the lid without raising the chute above the elevation of the sidewalk. After a slight turn, the lid is taken off, and the throwing in of the coal commenced. When finished, the lid is put in place on top of chute, the reverse turn given, which locks lid to chute, and allows the latter to be lowered to grade of pavement. The lid cannot be removed without raising the chute; and when the chute is lowered, the lid is secured and cannot tilt, as can ordinary covers, when carelessly replaced.

IMPROVED PROTRACTOR.

Regular Meeting, May 16th, 1885.—Mr. Kenneth Allen exhibited and described an Improved Protractor, designed by Mr. John R. Freeman, Member A. S.

C. E., Lawrence, Mass., and made by Messrs. Darling, Brown & Sharpe, Providence, R. I., with special regard to accuracy and finish. It consists of a plate 6 in. x 12 in., bearing an 11 in. semicircle graduated to 20 min. The vernier, reading to minutes, is carried on an arm, through the centre, to which may be accurately attached different arms, 20 in. long, graduated to mm., $\frac{1}{1000}$ ft., $\frac{1}{20}$ in., $\frac{1}{40}$ in., $\frac{1}{10 \times 5}$ in. and $\frac{1}{5 \times 10}$ in.

The error from eccentricity of centre is determined within $\frac{1}{4}$ min. The total error at any part of arc is believed to be less than $\frac{1}{2}$ min. In use, 100 angles are easily plotted in an hour, and in a year's work, its price—$130—is estimated to have been saved. The whole is of nickel-plated steel.

THE POLLUTION OF THE UPPER SCHUYLKILL.

Regular Meeting, May 16th, 1885.—Mr. Dana C. Barber, Assistant Engineer of the Philadelphia Water Department, in charge of Sanitary Surveys and Investigation of River Pollution, presented an account of the Pollution of the Upper Schuylkill—being a brief *résumé* of some of the more notable and peculiar features, viz.: the acid pollution from the coal mines, the cesspool drainage of Reading, the Pottstown water supply, the winter disturbances in the quality at Phœnixville, the drainage of State Insane Asylum at Norristown, etc.

The sulphuric acid from the mines about Pottsville has been decreasing since 1868 on account of the transfer of mining operations to the other side of the mountain, draining into the Susquehanna, and now amounts to but one-third of its former quantity. The most now comes from the region about Tamaqua. But few fish live in the river above Reading, and the water is unfit for use in boilers. At Reading, the acid is neutralized by lime-water from Tulpohocken Creek, sulphate of lime being formed and deposited. The water just below Reading would be very pure but for the foul drainage from that city—the greatest source of pollution in the valley. The most peculiar feature there was the underground strata of cavernous limestone, into which nearly half the cesspools and privy wells are dug, and thus drained of liquid waste by natural subterranean channels to the river.

At Pottstown, eighteen miles below the enormous pollution from Reading, the water supply was found to be drawn from the river, and that, too, at the lower end of the town—below the discharge of much domestic sewage from the town itself. The local physicians have protested against this practice in vain.

The water supply of Phœnixville, drawn from the Schuylkill above the town, was ordinarily very good, but at times, in winter, when the river was frozen over, became very bad. The author had discovered the cause of this to be due to the peculiar course of the channel and formation of the river bed just above the pumping station, which caused a deep ice jam that arrested the coarser organic impurities and sent them into the reservoir.

The pollution from Norristown was very serious, especially that from the State Insane Asylum near the town. No attempt to purify any kind of liquid waste before discharging it into Stony Creek has been made, except the water closet sewage (60,000 gallons per day, from 1200 people), which had for two years been treated as follows: the sewage was first settled in receiving basins and afterward filtered—first through blocks made of copperas, plaster of Paris and purifying lime of gas works, and then through finely pulverized blast furnace slag. By an ingenious arrangement,

the filters were cleaned by perforated water pipes passing through the bottom, flushing the accumulations back into the settling tanks from which the sludge was pumped by a steam ejector, and run by gravity to a distant part of the farm. This arrangement worked well, but on account of the nuisance from the unpurified sewage, it had been decided to dispose of the whole by sub-surface irrigation.

President deKinder

read, from a clipping of the *Public Ledger*, of recent date, the following expression used at a meeting lately held by the Homœopathic Society of this city—"In quality we have a fluid from which a dumb brute may well turn in disgust." Mr. deKinder said that he was bitterly opposed to the pollution of our drinking water; that he was against the admission of sewage and other deleterious matter into the river; that the intercepting sewer should be finished without delay; and that the great need, for improvement of the distribution system and of large storage basins, should be attended to at any cost. He also said that the idea of sewage matter being allowed to mix with our water supply was very disagreeable, and he would be opposed to it from a point of cleanliness, even if it had no effect upon the wholesomeness of the water.

But, while not wishing to defend, in any sense, either the pollution of the river or any delay in making the needed improvements, he must protest against such extravagant language as had been used by this Medical Society. There was abundant proof to show that impure water was not of necessity unwholesome, and eminent authorities were quoted to prove this.

He further stated that chemical analysis of water was not infallible, and that, at any rate, the chemist could only state the results of his analysis. The Sanitary Engineer was the proper authority to draw the conclusions and to sit in judgment upon the question of the wholesomeness or unwholesomeness of the water supply, for he could judge as to what the effects were in other places where water of a similar quality was in use.

Although heartily in favor of an improved supply, he must yet contend that the death rate of our own city showed that things were not so fearfully black as these gentlemen of the Homœopathic Society would have it. They had a perfect right to think as they pleased, but they should exercise caution before unnecessarily alarming the community. If the water were as vile as they would have it, why had he or his family never been warned by any medical authority against the use of it, notwithstanding several members thereof had been under medical treatment almost continuously within the past three or four years?

Few doubted that running water would purify itself. Exactly what effect the run between Manayunk or the Falls and his own residence had upon the quality of the water, he could not say, but at any rate, he himself and thousands of others drank it, if not with an absolute relish, at least without feeling any evil effects therefrom.

A PROPOSED REVIEW OF ENGINEERING LITERATURE.

Special Business Meeting, June 20th, 1885.—The Secretary presented the following communication from Prof. J. A. L. Waddell:

To the young engineer commencing the practice of his profession, and indeed to many engineers of considerable experience, one of the greatest difficulties encountered is to ascertain what has been written concerning any branch or subject of engineering,

and, of all that has been written, what is and what is not reliable. In this difficulty what is the young engineer to do?

There are but two courses open to him: the first is to search through such standard works as those of Rankine, Trautwine, etc.; and the second to consult some engineer of greater experience.

If he does the first, he may find what he wants; but he is liable to collect a mass of conflicting data, to choose from which will place him in as bad a predicament as before; it is not at all improbable, though, that he will fail to find any data whatsoever; for it is no unusual experience to discover in such a search everything except the one thing sought.

Then again, many of the technical books that one finds in libraries are antiquated: they were very good when they were written, but have served their day, and are now fit for nothing but to be shelved as curiosities of literature and historical references. On the other hand, a great deal of what is written is miserable trash, delusive alike to the mathematician and to the practicing engineer. Whole treatises are sometimes based on false assumptions, and others either contain so many mistakes or typographical errors as to render them entirely useless. The value of a book of reference depends often as much upon the proof-reader as upon the author.

As for the other alternative, the young engineer has first to ascertain who are the authorities upon the subject under consideration, and, second, how to consult them. Consulting by letter is generally very unsatisfactory, and consulting in person is often out of the question. Besides, the engineer consulted may not have the time or the inclination to furnish the information needed.

Such being the state of affairs, the questions arise "can anything be done to ameliorate matters," and, if so, "in what manner."

To answer these questions is the object of this paper.

The work to be accomplished can be divided into two parts: first, the collection and valuation of what has been already printed, and second, the improvement of future technical works. It is with the first of these divisions only that this paper aims to deal: the second will be discussed by the writer at some future time.

If the subject of engineering be properly divided, if all the literature upon each division be reviewed by two of the best authorities, the separate reviews collected in a book, and the whole thoroughly indexed, the first desired object will be accomplished.

Would not the publication of such a work be a good undertaking for the Engineers' Club of Philadelphia?

That, if undertaken at all, it must be done by a society is self evident, for no man is capable of competently reviewing the whole subject of Engineering Literature; nor is it likely that any engineer has enough personal influence to persuade others to help him in such a task.

In choosing the reviewer, however, the Engineers' Club should not confine itself to selecting from its own members, because many of those most competent for the work do not belong to the Club.

The book would simply be compiled and published by the Club, which would obtain credit for the treatise as a whole; but each reviewer's name should precede the work by him prepared.

In order to insure the success of any such undertaking as this, it should be established on purely business principles.

The total cost of the book would be small compared to that of nearly all other technical works, owing to the absence of plates and other illustrations; and as nearly every English speaking engineer would purchase a copy in any case, the price could be so adjusted as to insure a large profit over and above the total cost of publication, advertising, selling, etc. Of this profit a certain amount, say fifteen per cent., should go to the Club, and the remainder be divided among the reviewers. Of course it could not be expected that each reviewer's share would pay him for the time spent on the preparation of the MS., nevertheless it, in connection with the increase of knowledge and the reputation gained thereby, ought to be a sufficient inducement to most engineers to undertake the task.

Those best fitted for the work are of two classes, viz., authors of technical books, who are usually college professors, and practicing engineers, and it would be well to have one reviewer of each kind for each division. There is no one better fitted to review a subject than he who has already written a treatise thereon; but an author cannot very well review his own book, so it would have to be understood that the other reviewer would be responsible for that portion of the work.

In case of a disagreement between two reviewers, a referee could be appointed by the same committee that had engaged the reviewers. If thought advisable, the review of each book might be initialed so as to place the responsibility upon the proper party, the referee initialing any disputed portions.

In regard to the committee; it should consist of half a dozen leading members of the Club, who are residents of Philadelphia; and it might in some cases be well for them to consult other engineers as to who are best fitted for the work. They should take great care in making the divisions of Engineering, arranging so as neither to have too many reviewers, nor to make the amount of labor for any reviewers too great. After the division is made it should be published in the technical journals, and criticism thereon be invited; for, as the book would be prepared for the profession, it would be only fair to allow the profession to have something to say concerning the manner in which it should be prepared.

A certain date should be agreed upon, before which all the MS. must be handed in to the publishing committee; and the reviewers of each division should sign an agreement to have their MS. ready before the date appointed. The time allowed should be ample; and, in order to avoid delay, a rule should be made that no books issued after a certain date be reviewed in the first edition.

The names and addresses of the reviewers should be published from time to time in the principal engineering journals, in order that authors and publishers of technical books may send said books to be reviewed. The editors of engineering periodicals would, no doubt, very willingly insert anything to aid in such an enterprise.

The first step for the reviewers of each division to take should be to collect all the books containing anything upon the subject of the division; the next to cull from these all that are worthless or antiquated; the next to arrange the remainder as nearly as possible in their order of merit, so that it may be to the reader an understood thing that the best books come first upon the list, thus indicating to young engineers what are the best books to buy; and the next to divide up the work between the two reviewers.

The principal object of the work should be to review *books that are in the market,* nevertheless a few remarks upon the most important pamphlets, papers in society

transactions and technical journals, and books out of print would be very valuable, especially if it were stated where such pamphlets or books are to be found. It might be well to say what books are valueless, but this point needs consideration, because of the unpleasantness it might generate.

It might be better to review no books in foreign languages; for there would be no limit to the size of the work, if foreign literature were to be treated.

The preparation of a second edition would be an easy matter, the work consisting of the reviewing of books, etc., published since the first issue, the insertion of these reviews in their proper places, and the preparation of a new index.

In conclusion the writer hopes that the Club will look favorably upon his proposition; for, in his opinion, the publishing of such a treatise would be not only a great boon to the profession, but also a lasting credit to the Engineers' Club of Philadelphia.

ABSTRACT OF MINUTES OF MEETINGS.

Of the Club.

May 2d, 1885.—Business meeting.—President J. J. deKinder in the chair; 45 members and 5 visitors present.

The Secretary reported that the house No. 1122 Girard Street had been secured for the Club, and that the Board of Directors were taking such action as would enable us to occupy it at an early day.

Messrs. J. E. Codman and T. M. Rogers, Tellers, reported that 110 votes had been cast and the following gentlemen elected Active Members of the Club: Messrs. Harry B. Hirsh, Geo. B. Price, Louis Schutte, Max Livingston, John L. Gill, W. F. Dodge, S. P. Mitchell, Wm. H. Burr, Heber S. Thompson, Wm. J. Hoyt, and Frank H. Taylor.

Prof. L. M. Haupt, Chairman of Committee appointed at last meeting to prepare a Memorial to the Legislature of Pennsylvania upon the Continuation of the Second Geological Survey of the State, presented the following report from that Committee:

To the Honorable Lieutenant Governor Chauncey F. Black, President, and the Honorable Amos H. Mylin, President pro tem. of the Senate, and the Honorable James L. Graham, Speaker of the House of Representatives of Pennsylvania:

Whereas, The Engineers' Club of Philadelphia recognize the gross errors and discrepancies which exist in all of the best maps

which have been constructed of Pennsylvania and of individual counties in the State, which have been published since 1816, and which are based upon Melish's State Map, constructed under authority of the Legislature of that year; and

WHEREAS, There is a great demand among those citizens of the State interested in all surface improvements and in the development of the natural resources of the State, for an accurate map, which shall establish the true geographical position of every point on its surface north and south, and east and west from every other point, and the elevation of all points above tide, so that the citizens of the Commonwealth shall have correct maps of their respective townships and counties on which surface improvements may be outlined, and upon which surveyors can place land lines, and mining engineers and geologists can trace mineral outcrops and areas; and

WHEREAS, The Board of Commissioners of the Geological Survey have entered into negotiations with the United States Geological Survey, and the United States Coast and Geodetic Survey, and a plan of co-operation has been proposed by which the United States Surveys will expend in the State for a geographical and topographical survey $35,000 a year, if the State will expend $10,000 a year, and which co-operation now depends upon the granting of a State appropriation by the Legislature in accordance with the recommendations of the Board of Commissioners; and

WHEREAS, Such State maps are now being constructed by New York, Massachusetts and New Jersey, it is, therefore,

Resolved, By the Engineers' Club of Philadelphia, that they respectfully petition your Honorable bodies to speedily pass House Bill 497, entitled "An Act to provide for the continuance of the Geological Survey of the State," as originally introduced and committed to the Appropriation Committee of the House of Representatives, wherein an appropriation of $90,000 is asked, $20,000 of which provides for the continuance of topographical work and the commencement of the construction of an accurate map of the State, and your petitioners will ever pray.

Upon motion of the Secretary, the Report and Resolutions were unanimously adopted and the Chairman of the Committee em-

powered to forward the same, in proper form, to the Senate and House and to the individual members thereof.

The Secretary announced that he had referred the recently offered amendments to the By-Laws to the Committee, which now has the complete revision of the By-Laws in charge, and is actively pushing its work to completion.

Mr. T. Everett Austin presented a paper on Fast Passenger Locomotives.

Mr. Kenneth Allen presented extracts from a paper by Henry J. Barnes, M.D., on Purification of Sewage.

Mr. W. F. Newell, member of Civil Engineers' Society of St. Paul, introduced by Prof. Haupt, presented a description of the Borup Coal Chute.

May 16th, 1885.—Regular meeting.—President J. J. deKinder in the chair; 34 members and 2 visitors present.

Mr. Kenneth Allen exhibited and described an Improved Protractor, designed by Mr. John R. Freeman, Member A. S. C. E., Lawrence, Mass, and made by Messrs. Darling, Brown & Sharpe, Providence, R. I., with special regard to accuracy and finish.

Mr. Dana C. Barber, Assistant Engineer of the Philadelphia Water Department, in charge of Sanitary Surveys and Investigation of River Pollution, presented an account of the Pollution of the Upper Schuylkill.

It was discussed by President deKinder.

Mr. C. W. Buchholz presented notes as to the Connection of the Baltimore and Ohio Railroad with the Philadelphia and Reading Railroad, through the City of Philadelphia.

June 6th, 1885.—Special Business Meeting.—Past President Frederic Graff in the chair; 31 members present.

The Secretary reported from the Board of Directors that arrangements had been finally concluded with the Girard Estate, and that the building at No. 1122 Girard Street is to be occupied by the Club for a term of five years at an annual rental of $1,000, the Girard Estate to expend $1,000 in making the alterations and repairs desired by the Club.

The By-Laws, as reported by the Committee on revision of the

same, were then taken up and discussed in detail. Two amendments were made, and the revision, as thus amended, was offered in regular form as amendment to the present By-Laws.

The Secretary presented a communication from Mr. Wm. T. Blunt, Secretary of a Committee appointed by the Civil Engineers' Club of Cleveland to investigate the relation of Army and Civil Engineers in the Government service, and report a line of action in the premises. The communication requested that a similar committee be appointed by this Club. On motion, the consideration of the subject was postponed for the present.

On behalf of Prof. Louis H. Barnard, Mr. Dana C. Barber presented an illustrated article upon Stereographic Projection.

Mr. Percy T. Osborne presented an illustrated description of the Sand-Bag Embankment to close Little Inlet on Brigantine Beach, N. J., which was constructed by his father, Mr. Richard B. Osborne, C. E.

Owing to the lateness of the hour, the reading of the other papers was postponed.

June 20th, 1885.—Special Business Meeting.—Past President Lewis M. Haupt in the chair; 23 members present.

The revision of the By-Laws of the Club, as reported by the Committee having that work in charge and amended at the Special Business Meeting on June 6th, 1885, was adopted by unanimous vote.

The Tellers of Election, Messrs. J. E. Codman and T. M. Rogers, reported that 143 votes had been cast and the following candidates elected Members of the Club: Active Members, Messrs. Edward Longstreth, C. A. Sundstrom, H. N. Sims, F. L. Garrison, Herbert C. Felton, Geo. W. Hewitt, W. K. Martin, A. G. Mitchell, Wm. T. Forsythe, Chas. E. Taylor, Geo. S. Cheyney, Jr., Edward H. Johnston, Charles Wyeth, Rudolph Baizley and E. L. Corthell; Associate Members, Messrs. Wm. S. Moorhead, W. C. Strawbridge, J. Bonsall Taylor and Justus H. Schwacke.

The Secretary presented, from Prof. J. A. L. Waddell, a communication proposing that the Club organize a system of Review of Engineering Literature, and suggesting methods therefor.

The Secretary presented, for Mr. James Beatty, Jr., a paper upon the Relative Costs of Fluid and Solid Fuels.

Prof. L. M. Haupt announced, by title, a paper upon the Repairs to the Conduit of the Philadelphia Traction Company, which will probably be ready for publication during the summer.

The Secretary presented, for Mr. C. W. Buchholz, a Memorial of the late William Lorenz, reviewing his studies, his early experience, his career on the Philadelphia and Reading Railroad from topographer to Chief Engineer, his great scientific and practical ability, and last, but far from least, the extraordinary completeness of his manhood.

The Club adjourned for the summer, to meet at the call of the chair.

Of the Board of Directors.

May 2d, 1885.—Special meeting.—President J. J. deKinder in the chair.

The Secretary asked the Board to make provision for attention to the moving, furnishing and engagement of attendants for the new house. On motion of Col. Ludlow the President and Secretary were commissioned to attend to these matters, except as to the engagement of a janitor, which was referred to Mr. Cleemann, who had recommended a person to the Board for that position.

The Secretary presented an approximate statement of the finances of the Club to enable the Board to judge as to our ability to meet the additional expenses about to be incurred, and specially requested the Board to scrutinize the figures and to point out any error or provision which had been omitted or miscalculated.

The Board offered no amendment to the statement. The Secretary presented a letter dated May 2d, from Mr. S. S. Cavin, Agent Girard Estate, requesting a visit from our committee, the keys of No. 1122 Girard Street now being in his possession. The Board decided to inspect the house and make arrangements therefor in a body, and adjourned to meet at Office Girard Estate on Monday, 4th inst., at 4 o'clock p.m.

May 4th, 1885.—Adjourned meeting at Office Girard Estate, Twelfth and Girard Streets, Philadelphia, President J. J. deKinder in the chair.

The Board proceeded with Mr. S. S. Cavin, Agent Girard

Estate, to the prospective Club House at No. 1122, and made a careful examination of the premises.

It was then ordered that the Secretary should formulate the alterations and repairs which the Board had desired, and communicate the same to the agent of the Girard Estate.

The carrying out of wishes of the Board was committed to the President and Secretary of the Club.

May 12th, 1885.—Special meeting, 4 o'clock p.m.—President J. J. deKinder in the chair.

The Secretary presented a letter from Agent Girard Estate, of May 9th, stating that their committee had offered the house at $875 per annum without alterations, and at $1,000 per annum with desired alterations. The question was referred to the President, with request that he endeavor to make the best terms possible, and with full power to act in the matter and close the negotiations on behalf of the Club.

The Secretary requested the Board to define their action in referring, at recent meetings, the removal of the Club effects and the furnishing of the New Club House, to the President and Secretary. These officers were instructed to proceed in the matter of removal, fitting up and furnishing of new house, and authorized to use their discretion therein.

The Secretary suggested that some term should be adopted by the Board to designate our new quarters in our various published headings. After some discussion it was agreed that the headings should hereafter read:

"Engineers' Club of Philadelphia,
House, No. 1122 Girard Street,
Philadelphia, Pa."

June 6th, 1885.—Special meeting.—Mr. Frederic Graff in the chair.

The Secretary reported that he had arranged the back numbers of Proceedings in sets. It was ordered, that the following prices to members be adopted for each set, and that no set be broken in order to grant applications for single numbers; the prices of odd copies of back numbers, and copies of current numbers, to be the

same as heretofore. The reason for increasing the prices of partially broken sets is, that, in each of them, the percentage of missing numbers will diminish as the future complete volumes are added to each.

Prices to members, of Vols. I to IV (both inclusive) of Proceedings:

Complete,		$15 00
Wanting:	Vol. II, No. 1,	12 00
"	Vol. II, No. 1, and Vol. IV, No. 1,	10 00
"	Vol. II, No. 1, Vol. III, No. 4, and Vol. IV, No. 1,	8 00
"	Vol. II, No. 1, Vol. III, Nos. 3 and 4, and Vol. IV, No. 1,	7 00
"	Vol. II, No. 1, Vol. III, Nos. 3, 4 and 5, and Vol. IV, No. 1,	6 00

The Secretary presented a letter from Mr. S. S. Cavin, Agent Girard Estate, stating that their committee had decided to lease the Club the house at 1122 Girard Street, either at $875 per annum without alterations, or at $1,000 per annum for five years with alterations not to cost over $1,000. The Secretary was instructed to lease the building under the latter conditions.

July 13th, 1885.—Special meeting at No. 1122 Girard St., at 4 o'clock P.M., being the first Board Meeting since occupying the new house; President deKinder in the chair.

The Secretary stated that a question had arisen as to what portions of the building should be occupied by the janitor. The meeting made an examination of the upper part of the house and decided that the janitor's quarters shall consist of the two garret rooms in front building; and that he be furnished with sufficient gas and coal for necessary purposes in addition to rooms and wages.

The Secretary reported that a heavy duty charge had been made against certain books presented to the Club, and recommended decided action, in view of the great injustice done the Club by this and other charges which had been made contrary to the express letter and spirit of the law. He was instructed to prepare the papers for appeal to the Treasury Department.

CONTRIBUTIONS TO THE LIBRARY

FROM MAY 1ST TO SEPTEMBER 8TH, 1885.

From the INSTITUTION OF CIVIL ENGINEERS, London.

Evans—Physiography.
Parsons & Shellshear—Steam Tramways.
Bramwell—Address, January 13th, 1885.
Marchant—Tekapo Bridge.
Hamilton-Smythe—British and Metric Measures.
Smart—Steam Boilers.
Webb—Standard Engine Shed.
Walther-Meunier — Brauer's Dynamometric Brake.
Unwin—Friction of Disks.
Guillain—Cost of Dredging.
Turner—Gauging of Flowing Water.
Longridge—Guns as Thermodynamic Machines.
Craig—Discharge from Catchment Areas.
James—Removing Rock Under Water.
Dalrymple-Hay—Trigonometrical Surveying.
Howard—Secondary Batteries.
Webb—Steel Permanent Way.
Pole—Water Supply.
Pole—Aërial Navigation.
Noble—Heat-Action of Explosions.
Kirk—Refrigerating Machinery.
Kinder—Electric Blasting in China.
Kidd—Blyth Harbour.
Deprez & Leblanc—Various Methods of Traction.
Baker & Barry—Metropolitan Railways.
Williams—Speed of Steam Engines.
Anderson & Ogston—Purification of Water.
Birch—The Pollution of the River Thames.
Brounger—Cape Government Railways.
Hallé—Public Work in Orange Free State.
Tripp—The River Buffalo.
Abstracts of Papers in Foreign Transactions and Periodicals.

From the SOCIETY OF ENGINEERS, London.

Transactions. Bound.

From the NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, Newcastle-upon-Tyne.

Transactions—Vol. XXXIV, Parts III and IV, 1885.

From the AËRONAUTICAL SOCIETY OF GREAT BRITAIN, London.

Annual Reports for 1883-84.

From the SOCIETY OF CIVIL ENGINEERS, Paris.

Mémoires—February, March and April, 1885.

From the NORWEGIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Kristiania.

Norsk Teknisk Tidsskrift—Part III, 1885.
Indberetning fra Kontorchef Fenger-Krog om hans Stipendiereise. Sommeren, 1884.

From the SWEDISH SOCIETY OF CIVIL ENGINEERS, Stockholm.

Proceedings—Parts I and II, 1885.

From the SAXONIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Leipzig.

Der Civilingenieur.

From the PORTUGESE SOCIETY OF CIVIL ENGINEERS, Lisbon.

Revista de Obras Publicas E Minas—March-April, May-June and July-August, 1885.

From the ARGENTINE SCIENTIFIC SOCIETY, Buenos Aires.

Anales—March, 1885.

From L'ADMINISTRATION DES PONTS ET CHAUSSÉES, Paris.

Annales—April, May, June and July, 1885.
Personnel—1885.

From the AMERICAN SOCIETY OF CIVIL ENGINEERS, New York.

Transactions—February, March, May and June, 1885.

From the AMERICAN INSTITUTE OF MINING ENGINEERS, New York.

Transactions—Advance Sheets.
" Vol. XIII, Feb., 1884, to June, 1885.

From the AMERICAN WATER WORKS ASSOCIATION, Mr. J. H. Decker, Secretary, Hannibal, Mo.

Proceedings of 5th Annual Meeting—Boston, 1885.

From the AMERICAN IRON AND STEEL ASSOCIATION, Philadelphia.

Annual Report of Secretary—May 15th, 1885.

From the U. S. ASSOCIATION OF CHARCOAL IRON WORKERS, Philadelphia.

Journal—April and June, 1885.

From the AMERICAN SHIPMASTERS ASSOCIATION, New York.

Record of American and Foreign Shipping—Nos. 9, 10, 11, 13, 14, 15, 16, 17. 1885.

From the INTERNATIONAL INSTITUTE FOR PRESERVING AND PERFECTING WEIGHTS AND MEASURES, Cleveland, O.

The International Standard—May and July, 1885.

From the AMERICAN PHILOSOPHICAL SOCIETY, Philadelphia.

Proceedings—April, 1885, Part II.
" July, 1885, " III (containing Old Minutes of the Society from 1743 to 1838).

From the AUSTRIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Vienna.

Wochenschrift.
Zeitschrift—Parts I and II, 1885.

From the WESTERN SOCIETY OF ENGINEERS, Chicago.

Proceedings—Slips.

From the CONNECTICUT ASSOCIATION OF CIVIL ENGINEERS AND SURVEYORS, New Haven, Conn.

Minutes of Regular Meeting—April 15th, 1885.

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Proceedings of 5th Annual Meeting—January, 1885.

From the ASSOCIATION OF ENGINEERING SOCIETIES, New York.

Journal—May, June, July and August, 1885.

From PROF. H. KATO, President of the University of Tokio, Japan.

Memoirs of the University of Tokio.—A System of Iron Railroad Bridges for Japan. Text and Tables and Plates. 1885.

From the SCHOOL OF MINES, COLUMBIA COLLEGE, New York.

Quarterly—March, 1885.

From the MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Boston.

Abstracts of Proc. Soc. of Arts. 1883–84.
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From the PHILADELPHIA SOCIAL SCIENCE ASSOCIATION.

Rembaugh—Alcohol. 1885.

From the FRANKLIN INSTITUTE, Phila.

Journal—June, July, Aug. and Sept., 1885.
Report of Examiners International Electric Exhibition—Secs. V, VI, VIII and X.
General Report of Chairman of Committee on Exhibitions. 1885.
Report of Special Committee to Determine Efficiency and Duration of Incandescent Electric Lamps. 1885.

From the GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA, Ottawa.

Report of Progress and Maps for 1882–84.
Catalogue of Canadian Plants—Part II, 1884.
Maps to illustrate Reports.

From the BOSTON PUBLIC LIBRARY.

Bulletin—Spring Number, 1885.

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From the U. S. GEOLOGICAL SURVEY, Washington, D. C.

Lord—Comstock Mining and Miners. 1883. Bound.
Irving—Copper Bearing Rocks of Lake Superior. 1883. Bound.
Fontaine—Older Mesozoic Flora of Virginia. 1883. Bound.
Curtis—Silver-Lead Deposits of Eureka. 1884. Bound.
Walcott—Paleontology of the Eureka District. 1884. Bound.

From the SMITHSONIAN INSTITUTION, Washington, D. C.

Report. 1883. Bound.

From the DEPARTMENT OF INTERNAL AFFAIRS of PENNA., Harrisburg.

Annual Report of Secretary—Part III. Industrial Statistics. 1884.

From the SECOND GEOLOGICAL SURVEY OF PENNA., Philadelphia.

Grand Atlas—Div. III, Part 1.
Report—F 2, Part 1.
Atlases—X and AA, Part 1.

From Messrs. A. P. TURNER & CO., London.

Financial Letters—Nos. 85 and 86.
The Western Union Telegraph Co.

From the Author, MR. D. P. BLACKSTONE, Berlin, Wis.

The Attraction and the Figure of Equilibrium of a Rotating Fluid Mass and the Interior Density and Temperature of the Earth. 1885.

From the Author, MR. HENRY P. M. BIRKINBINE, C. E., Philadelphia.

Report on Improving the Drainage of Land of Kingsessing and Tinicum Meadow Co. 1884.

From the Author, MR. ELIOT C. CLARKE, C. E., P. A. Engineer in Charge.

Main Drainage Works of the City of Boston. 1885. Bound.

From the Author, PROF. H. CARVILL LEWIS, Philadelphia.

Marginal Kames—1885.

From MR. D. W. C. CREGIER, Commissioner of Public Works, Chicago, Ill.

9th Annual Report—Dep. Pub. Works for 1884,

From the Author, MR. S. B. FISHER, Pa. Co., Pittsburgh, Pa.

Table of Cubic Yards in Lengths of 100 Cubic Feet. 1885.

From the Author, MR. J. B. JOHNSON, care of Messrs. John Wiley & Sons, N. Y.

Stadia Reduction Diagram to accompany Topographical Surveying.

From the Publishers, MESSRS. JOHN WILEY & SONS, New York.

Merriman—Mechanics of Materials. 1885. Bound.

From the Author, MR. R. MEADE BACHE, Active Member of the Club.

The Latest Phase of the Great Pyramid Discussion. 1885.

From MR. P. H. BAERMANN, Chief Engineer, Active Member of the Club.

Annual Report of Water Commissioners of Troy, N. Y., for 1884.

From the Author, MR. E. L. CORTHELL, Active Member of the Club.

Discussion of "The Radical Enlargement of the Erie Canal" by Mr. E. Sweet, C. E. 1885.

From MR. E. S. HUTCHINSON, Active Member of the Club.

Index—Vols. I to X., Trans. Am. Inst. Min. Engrs. Bound.

From MR. C. FREDERICK MOORE, Active Member of the Club.

The "Scientific American"—File for 1877 Complete.

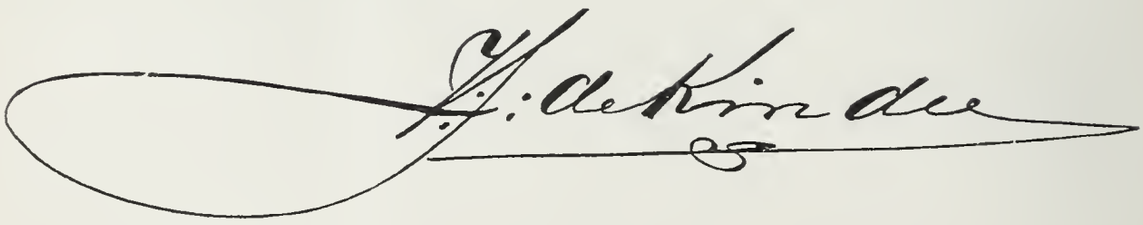
ADDITION TO EXCHANGE LIST.

TECHNICAL SOCIETY OF THE PACIFIC COAST, San Francisco, Cal.

BOOK NOTICE.

A TEXT-BOOK OF THE MECHANICS OF MATERIALS. By Mansfield Merriman, Professor of Civil Engineering at Lehigh University. New York, John Wiley & Sons, 1885.

This book is one of the latest candidates for public favor as a manual of instruction in practical mechanics for the use of civil engineers. The mathematical deductions of the laws of strength and stiffness of beams, supported, fixed, and continuous, under compression, tension and torsion, and of columns, are elegant and complete. As in previous books by the same author, plenty of practical, original, and modern examples are introduced as problems, and the capability of their solution proves a correct understanding of the various articles in the book. The proof reading has not been done as well as it should have been, but we hope that a new edition will soon be called for, in order that this defect may be remedied.



PRESIDENT DURING THE EIGHTH YEAR OF THE CLUB, A.D. 1885.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

Vol. V.] FEBRUARY, 1886. [No. 3.

ANNUAL ADDRESS

OF

JOSEPH J. DE KINDER, Retiring President.

Read January 9th, 1886.

FELLOW MEMBERS:—Although the year, which has just closed, has been more remarkable for stagnation in nearly every branch of business than for the birth of large engineering enterprises, still much has been accomplished, and the consideration of many important questions in the field of engineering has received sufficient impetus to warrant the belief, that with the return of the flood-tide of business activity (of which, let us hope the new year may be the harbinger) we may be able to chronicle the actual development.

The Panama Canal, like its predecessor, the Suez Canal, has been, as usual, the object of a great deal of criticism. On July 29th of last year Baron de Lesseps reported to the Council of Administration as follows: Instead of one hundred and fifty-six million cubic (156,000,000) yards to be excavated as first anticipated, the entire amount will probably fall below one hundred and twenty million (120,000,000) yards—the mean price for the removal of a cubic yard of earth will be about fifty-four (54) cents and of rock, one dollar and thirty cents ($1.30). At these figures

the total cost of the canal would be about one hundred and forty million dollars ($140,000,000) upon the day of its opening. To this sum for excavation must be added the expenses of the administration, and interest and obligations, to arrive at the total as announced by the International Congress. This Congress calculated the cost of the canal completed at two hundred and forty million dollars ($240,000,000)—about ninety-five million dollars ($95,000,000) had already been expended or pledged for work on the canal, and over fifteen million (15,000,000) cubic yards of material had been removed. The work is being done by twenty-one different contracting firms, divided as follows: One English contracting firm, one million six hundred thousand dollars ($1,600,000); two American contracting firms, ten million eight hundred thousand dollars ($10,800,000); one contracting firm of the United States of Colombia, four hundred and sixty thousand dollars ($460,000); ten French contracting firms, twelve million six hundred and eighty thousand dollars ($12,680,000); one contracting Holland firm, eighteen million dollars ($18,000,000); three Italian contracting firms, one million one hundred thousand dollars ($1,100,00); from Sweden one contracting firm, one hundred and thirty thousand dollars ($130,000); one Swiss contracting firm, two million five hundred and twenty thousand dollars ($2,520,000)—total, forty-seven million two hundred and ninety thousand dollars ($47,290,000).

We hear it announced by some of the critics that nearly one-half of the intended cost of the canal has been expended and that only a beginning has been made with the work—some add that it will take fourteen years to complete the canal at the rate of progress as made in the first half of 1884. I have been in correspondence with Mr. Thiange, a Member of our Club, now employed at the deep cut of Culebra, and also with some of the contractors, whom I have known for nearly twenty years, and men of a world-wide reputation for skill and perseverance, and to the words of whom I certainly have reason to attach more importance than to croakers, and from each and every one I have the positive assurance that the canal will be finished not later than 1889, and possibly by the end of 1888. The work on the canal is divided into thirteen sections, of which the Culebra sec-

tion is by far the most difficult, since it comprises the removal of some twenty-six million (26,000,000) yards of material in a length of two thousand one hundred and eighty-seven (2,187) yards or, say twelve thousand cubic (12,000) yards for every yard in length of canal, yet the contractors anticipate no insurmountable difficulty in completing this, the giant work of the canal, in the time specified, notwithstanding that only over one million (1,000,000) yards had been removed by the first of December last. It should be borne in mind that all the material to complete and push this work is very nearly all on hand, and that the enormous number of dredging machines, excavators, locomotives, tracks, cars, steam-engines, and all the many other appliances required, and the quarters for the housing of thirty thousand laborers, necessarily demands a very large outlay, and it is not to be wondered at that so large a sum has already been expended—but the great difficulty has been surmounted—out of chaos order has been established, and the work fairly commenced in the summer of last year, is now being pushed energetically over the whole length of the canal.

The cuttings commence at Colon; from this place to St. Pablo it does not exceed forty-three feet in depth, thence the ground rises gradually until at Gorgona, twenty-five miles from Colon, the depth varies from sixty-five to one hundred and twenty-four feet; between the twenty-fifth and the twenty-seventh miles, depths are met of from one hundred and ninety-four to two hundred and fifty-two feet, and at Culebra it is two hundred and eighty-six feet. After the thirty-seventh mile the cut reduces again to forty-five feet and less. The dam at the Chagres River will be twenty-six hundred feet long from hill to hill, from Cerro Cruz to Cerro Obisco, and one hundred feet in height, capable of retaining nearly nine hundred million (900,000,000) cubic feet of water, which will be available for supplying the canal. The greatest rainfall noted has been thirty-two inches in one month. The difference in water-level at Colon, between high and low water marks, is twenty-four inches; but on the Pacific side of Panama the average is thirteen feet three inches, and the maximum nearly twenty feet. The high water at Colon is nine hours later than Panama, consequently half-tide at one place corre-

sponds with high or low water at the other, the difference therefore between the tide-levels may be equal to one-half the rise on the Panama side.

The canal, as you know, will be finished in open cut from Colon to Panama, and will be provided at Panama with locks and flood-gates to allow of the passage of ships at all stages of the tide. Total length, forty-five miles.

What the financial results will be to the stockholders of the canal can only be surmised. In 1860 nearly all the newspapers in Europe, and especially the English papers, ridiculed the possibility of the Suez Canal ever paying any interest. The actual result has belied the prophecy, and I, for one, sincerely hope that the Panama Canal will be as successful in every way as the Suez Canal has proved to be.

The Manchester Ship Canal is as yet in prospectus, although this important undertaking has been chartered by Parliament and indications point to an early commencement of operations. This canal will serve a district covering nearly eight thousand (8,000) square miles, with a population of seven million (7,000,000) people. The largest vessels will be able to reach Manchester direct, without breaking cargo. It is calculated that the probable cost of the canal will be forty million dollars ($40,000,000). It will be thirty-five miles in length, with twenty-six feet depth of water and one hundred and twenty feet width at the bottom. The level of the Manchester docks, which are over sixty feet above ordinary tide-level, will be reached by four sets of locks—each set will comprise a dock, five hundred and fifty by sixty (550x60) feet for the largest class of vessels; one, three hundred by forty (300x40) feet for ordinary sized vessels; one, one hundred by twenty (100x20) feet for small coasters and barges. These locks will be made to work altogether by hydraulic power and will allow vessels to pass in fifteen minutes. There will be large docks at Manchester, Salford, and Warrington, with a water area of nearly ninety acres and containing over four miles of quays, besides numerous quay-spaces and wharves along the line of canal. It is calculated that within five years from the opening of the canal, the traffic will amount to nearly nine million (9,000,000), tons giving a net income of seven million five hundred thousand dollars ($7,500,000).

The Suez Canal, which was opened on November 17th, 1869, to the commerce of the world, notwithstanding all the predictions of its impossibility from a financial point of view, has become totally inadequate to the demands of commerce. It has therefore been decided by the International Commission, which met at Paris on November 25th, 1884, and afterwards by the General Board of Directors in January of last year, to accept the proposition of the Executive Committee of the Canal, to increase its efficiency. The principal points are as follows: The depth of the canal will be increased to twenty-nine feet six inches below low-water level, the bottom of the canal to be extended to one hundred and twenty-one feet. The present depth is twenty-six feet two inches and the width at bottom seventy-two feet. The length is ninety-seven and a half (97.5) miles from sea to sea, width at surface one hundred and ninety-seven feet. The total amount of earth-work to be removed is estimated at ninety-one million cubic yards and the cost at forty-two million dollars ($42,000,000).

In July, 1870, the number of vessels which passed through the canal was thirty-nine, with a gross tonnage of fifty-six thousand (56,000) tons, the receipts being a little over eighty-six thousand dollars ($86,000). In July of 1885, one hundred and forty-one vessels passed through the canal from the Mediterranean, and one hundred and sixty-three from the Red Sea; the gross tonnage was nearly nine hundred and forty-seven thousand tons (947,000) and the total receipts over one million dollars. It is also mentioned that the chief element of return freight in July (meaning of course from the Red Sea) was grain, amounting to sixty-four thousand four hundred and fifty (64,450) tons.

The report of the work done on the Canal of Corinth shows that satisfactory progress has been made, the excavations per month having increased from twenty-four thousand (24,000) to one hundred and fifty-six thousand (156,000) cubic yards. In the first eighteen months, four hundred and fifty-seven thousand (457,000) cubic yards were removed. In the following twelve months, namely in 1884, one million and eighty-five thousand (1,085,000) cubic yards, and, for the first six months of 1885, nine hundred and thirty-six thousand (936,000) yards. The work con-

nected with this enterprise, including the breakwaters at Isthmia and Posidonia, and an iron bridge of two hundred and sixty feet span across the canal, one hundred and forty-one feet above the water surface for the Pire-Peloponise Railway, is well under way.

The German Bundesrath has unanimously approved a bill for the construction, at a cost of nearly thirty-four million dollars ($34,000,000), of a ship canal to serve military and commercial purposes, between the Baltic and the North Sea, by way of the Elbe.

The Chesapeake and Delaware Free Ship Canal is as yet but a thing on paper.

I quote from Captain Tuttle of the United States Army in his report. At the present moment, when Congress and the country are awakening to the need of ships and forts for the defence of our coast cities, they have an opportunity in the fact, that competent government engineers, in their official reports in regard to this canal, have recognized the vast importance of deep water connection between the Chesapeake and Delaware Bays, as a means of facilitating the defence of Philadelphia, Baltimore, Annapolis, and Washington, in case of war with some great naval power. It may be assumed, that if a war with one of the great naval powers should arise, and the mere appropriation of money could provide such a channel of communication between the bays, the amount would be at once provided without hesitation. If to the national importance of the work, as a means of military defence to three of the most considerable of the cities on the Atlantic, be added that of reducing the distance from Chicago, St. Louis, Louisville, and other western points to Liverpool by two hundred miles, the time of steamers by twenty-four hours, and the cost of carriage of grain by one and one-half cents per bushel, the claim of this work upon the attention of the national legislature is seen to be indisputable. The cost of a ship canal, one hundred feet wide at bottom and twenty-seven feet deep by the Choptank route—the only route worth a moment's consideration, was estimated, allowing for all contingent expenses, eighteen million one hundred and eighty-four thousand seven hundred and sixty-six dollars ($18,184,766)—an inconsiderable sum in view of the great benefits, military and commercial, to result to the nation from its completion.

The Hennepin Canal, designed to connect the Mississippi with Lake Michigan, the St. Lawrence, and the Atlantic, is also in statu quo.

The improvements in the Seine have resulted in a large increase in the commerce between England and Paris by water direct—one-half of the coal supply of Paris being delivered in English bottoms. The northern coal proprietors of France complain bitterly of this, and a scheme has been brought forward for a canal to Paris from Dunkirk, at a cost of twenty-one million of dollars ($21,000,000). This scheme would give the coal proprietors of the north of France a preference over foreign merchants.

It is also proposed to connect the Gulf of Siam with the Indian Ocean, taking advantage of the present rivers, and following the bed of the River Tagons to the Gulf of Siam. The canal would be sixty-six miles long, and its cost is estimated at twenty million dollars ($20,000,000).

In the work of draining large areas, Russia leads. Since 1870 she has been engaged in draining the Pinsk Marshes on the Russia-Polish confines. Four million acres have been reclaimed by the construction of thousands of miles of ditches and canals, some of which are navigable by boats of from two hundred to three hundred tons burden. One hundred and twenty miles of canals and ditches are now in course of construction, and an additional area of three hundred and fifty thousand acres will be drained thereby. Of the four million acres drained, six hundred thousand consisted of sheer bog, which has been converted into meadow lands. Nine hundred thousand acres have been converted into timber land, and the balance has been used for cultivation; nearly two hundred bridges were built, and some twenty-thousand miles of unmapped country was surveyed.

A joint survey has been recommended by the Governors of Arkansas and Missouri of the sunken lands in south-east Missouri and north-east Arkansas. There are four million (4,000,000) acres of land subject to overflow from the White Water, Carter, and Black Rivers, all of which can be made valuable land.

Of bridges commenced or continued during the past year, the great Baltimore and Ohio Railroad Bridge near Havre de Grace

stands out pre-eminently as one of the most difficult and grandest structures in this country. The length of this bridge is as follows: Between first abutment and pier No. 1, two hundred and twelve feet of iron viaduct; between pier No. 1 and pier No. 2, four hundred and eighty feet of deck span; between pier No. 2 and pier No. 3, four hundred and eighty feet of deck span; between pier No. 3 and pier No. 4, four hundred and eighty feet of deck span; between pier No. 4 and pier No. 5, a five hundred and twenty feet through span; between pier No. 5 and pier No. 6, a four hundred and eighty feet deck span; between pier No. 6 and pier No. 7, one thousand nine hundred and forty-one and fifteen-hundredths (1,941.15) feet of iron viaduct and masonry pedestals; between pier No. 7 and pier No. 8, three hundred and eighty feet of deck span; between pier No. 8 and pier No. 9, five hundred and twenty feet of deck span; between pier No. 9 and pier No. 10, three hundred and eighty feet of through span; between pier No. 10 and pier No. 11, two hundred feet of deck span, and between pier No. 11 and the east abutment, an iron viaduct of two hundred and forty-two feet. The total length of the structure is six thousand three hundred and fifteen and fifteen-hundredths (6,315.15) feet between abutments. Five of these piers were sunk to solid rock, through water, sand, and silt, to a depth varying from nearly sixty to nearly eighty feet. It is expected to have the bridge ready for traffic next April.

Work on the Tay Bridge for the Tay Viaduct, which is being constructed at the side of the bridge which was destroyed in December, 1879, is making good progress. The length of this bridge is ten thousand eight hundred (10,800) feet, the number of spans is eighty-five, varying from fifty to two hundred and thirty feet, the greatest height of rails above high water being eighty-three feet, and, at the navigable channel in the middle of the river, the clear headway for shipping is seventy-seven feet.

On the Forth Bridge work is also progressing favorably. This bridge was commenced in January, 1883, has a total length of nearly a mile and a half. There are two spans of one thousand seven hundred and ten feet each; two spans of six hundred and seventy-five feet each; fifteen spans of one hundred and sixty-eight feet, and five spans of twenty-five feet. The clear headway

is one hundred and fifty feet above high water, and the tops of the cantilevers are over two hundred feet higher still.

The superstructure will take over forty-five thousand (45,000) tons of steel, and the piers will take over one hundred and twenty thousand (120,000) cubic yards of masonry. Each of the seventeen hundred and ten feet spans is made up of two cantilevers, projecting six hundred and eighty feet, and a central girder connecting the same, three hundred and fifty feet in length. The cantilevers are three hundred and forty-three feet deep over the piers, and forty feet deep at the ends.

The contracts for the new St. Lawrence Railroad Bridge have recently been awarded. There will be three girders, eighty feet long; eight spans of two hundred and forty-two feet from centre to centre, and two spans across the steamboat channel of four hundred and eight feet each, making a total of three thousand five hundred and seven feet, from the face of the abutment at Lower Lachine to the pier of the Caughawaga Shore—the river at this point being thirty-three hundred (3,300) feet from shore to shore. The spans will be built on the cantilever principle, with a clear headway of sixty feet for vessels at the summer stage of water-level. The bridge will be built almost entirely of steel.

The bridge across the Ohio River at Henderson, Kentucky, was opened for traffic in August last. This structure is thirty-two hundred feet long, including sixteen piers; spans of two hundred and fifty feet each, except the main channel span, which is five hundred and twenty-five (525) feet long, one hundred and three feet six inches above low water, and fifty-seven feet above high water. The approaches to this bridge are by trestles and embankments, the trestle work on the Indiana side being three miles in length.

The great Saint John Steel Cantilever Bridge was opened for general traffic on the first day of October. The main river bridge consists of a central span of four hundred and seventy-seven feet, supported on granite piers which are nine by twenty-seven and one-half (9x27.5) feet on top, the east pier being ninety-six feet high and the west pier about fifty feet high. The cantilever arms are one hundred and forty-three and a half (143.5) feet on each side of the pier at the east side, and one hundred and ninety-

one (191) feet at the west side, the end of the east arm being supported on masonry abutments and on an excavation made in the solid rock, and the west arm being supported by a granite pier, eight by thirty-four (8x34) feet at the top and about forty feet in height.

The work on the new Croton Aqueduct has been pushed with unceasing activity. According to the latest reports, the total progress made up to November last is twenty-five thousand one hundred and eight (25,108) feet in the tunnel proper, exclusive of over three thousand (3,000) feet of lineal shaft-sinking. As the total length of the tunnel from the Croton Lake to the Harlem River is one hundred and forty-eight thousand six hundred and ninety-two (148,692) feet, the percentage of driven tunnel is seventeen. It is to be regretted, that this noble work should have already cost so many lives. The aqueduct, as now being built, will have a maximum flowing capacity of three hundred and twenty million (320,000,000) gallons per day from Croton, New York, to New York City boundary line, where it is designed to construct the distributing reservoir to supply the annexed district. A part of the supply being thus diverted, the remaining portion of the aqueduct has a flowing capacity of two hundred and fifty millions (250,000,000) gallons per day. It is estimated that the Croton water-shed can be relied upon to furnish two hundred and fifty million (250,000,000) gallons daily, even in years of extreme drought.

The Quaker Bridge Dam will increase the area of water-shed to three hundred and sixty-one square miles, and the reservoir thus formed will have a capacity of over thirty-two billion (32,000,000,000) gallons. The dam will be built of solid masonry, one hundred and seventy-eight feet high above the river bed. The foundation will extend to bed rock one hundred feet. The total height, for a distance of over four hundred feet in the deepest part of the valley, will be about three hundred feet, the width of the dam at the base will be two hundred feet, and the extreme length one thousand three hundred (1,300) feet.

The aqueduct for supplying Washington with water is also being pushed vigorously forward. The tunnel has a length of twenty thousand seven hundred and fifteen (20,715) feet, and its

cross-section is eleven feet wide by seven and a half feet high. The entire work is in hard solid rock, with the exception of a short section at the inlet shaft.

The Mersey Tunnel was opened in the early part of last year. Work was commenced in 1880, and once commenced, it was pushed with the greatest energy. It has been built thirty feet below the bed of the Mersey. The material is sandstone rock, which forms an admirable material to work upon, able to support itself and to endure the work of blasting. The tunnel only required lining with brick for the purpose of stopping out the percolation of water. For the like reasons the character of the stone has enabled portions of the tunnel to be built under the streets of Liverpool and Birkenhead, without the purchase of buildings and land. The form of the tunnel is that of a tapered oval. It is twenty-six feet in width and twenty-one feet in height, the invert being nearly equal in form to the arched portion overhead. There is a drainage heading below the tunnel, which runs continuously with the tunnel itself—seven feet in diameter. Into this, at intervals, the water entering the tunnel is pumped and the tunnel is in this way kept dry. There is a large railroad station on the Liverpool side, four hundred feet long by fifty feet wide, and thirty-eight feet in height, provided with platforms and provisions for shafts, capable of elevating two hundred and forty passengers to the level of the street in forty seconds. The fans for ventilating the tunnel are two in number, one forty feet, and the other thirty feet in diameter. A ventilation heading is cut alongside of the tunnel in the rock, one thousand yards long and seven feet in diameter. A station similar to the one in Liverpool is being completed on the Birkenhead side. It is intended to continue both ends of the railway tunnel ultimately to the surface and connect with the main lines converging at Liverpool from all directions.

The project of tunnelling the British Channel has again been revived, and, from the interest taken in this project, both in England and France, the outlook bids fair to see this scheme take definite shape in the near future.

Another great work now under consideration is the Prince Edward's Island Tunnel, which is intended to connect Prince

Edward's Island with the mainland and thus keep communication established, which at present, in winter time, due to the immense quantities of floating ice passing through Northumberland Strait, makes the transfer by ice boats a dangerous one. The tunnel proposed would be located between Capes Traverse and Torquentine, a distance of eight and a half miles. A survey shows the depth of water on the line to vary from six to seventy-two feet, with an almost level sea bottom. The bottom is sand for twelve feet in depth and then for a depth of sixty feet a tough clay. It is estimated that this tunnel will cost about two millions of dollars.

As a remedy against the bridge nuisance in Chicago, an immense tunnel under the Chicago River is proposed: the cost is estimated at twelve hundred thousand dollars ($1,200.000).

The Tehuantepec Ship Railway still has many advocates. It would be impossible, in a short resumé like this, to describe at length the engineering aspect of this ponderous work; besides it has been already so fully described in almost every scientific journal, that I doubt not every member is fairly well acquainted with it.

The fact that an English Company is about to build the Chignecto Ship Railway across the width of Nova Scotia Peninsula, between the Gulf of Saint Lawrence and the Bay of Fundy, on plans similar to those of Captain Eads, is conclusive proof that this scheme, although it may be looked upon by some with suspicion as to its practical work, is considered by prominent engineers as perfectly feasible.

Railroad building has received an impetus both in China and Japan. Work is to be commenced in the latter country on five different lines, one of four hundred and fifty miles in length, one of two hundred miles, one of one hundred and fifty, and two of seven miles each. In China a road one hundred miles in length is under consideration for an early commencement, from Tak Ho, at the mouth of the Yellow Sea, to the Pyho, a point about twenty-five miles east of Pekin. It is generally reported that all this work is to be done with European capital, and will be built and equipped with European material, which, to say the least, is to be regretted, in view of the facilities this country possesses

for turning out railroad materials and for building railroads, I think, superior to any country in the world.

Russia is also building a strategetic railroad to the Austrian frontier. In connection with this the *Brooklyn Eagle* remarks as follows: "You know what a strategetic railway is, do you? Buys its right of way from the farmers for an annual pass, then gets all the land condemned and takes up the passes, then gets a state grant of two or three counties for the directors, buys its iron on long time,—pays for its grading with construction bonds, issues equipment bonds to pay for rolling stock, borrows all the money in the country on the mortgages, calls in everything outstanding and changes it for a deficit, changes its name from the North and South Air Line to the East and West Shore Line, divides the swag among the directors and runs the road with a deficit. It may be new in Russia, but it is an old thing with us —the country is just full of strategetic railways."

I do not know whether there is any truth in this, and only add, that I trust that this is an overdrawn picture.

The great colossal passenger station of the London and Southwestern Railway was declared complete in September last. Twenty-five acres of land are roofed in, and the building covering this area contains fifteen platforms and nineteen distinct lines of rails, aggregating a length of four miles. Its signal box contains one hundred and eighty levers. Eight hundred houses have been demolished during the building, and a population of three thousand people displaced. The entire cost has been one million seven hundred and fifty thousand ($1,750,000) dollars. It is said that there is no minute through the day during which some train does not arrive or depart at this station.

The Meiggs Railway, an experimental road of the single rail type, is being constructed from Boston to Cambridge. It will be an elevated structure on pillars. The projectors of this system claim many advantages over the ordinary elevated railroad system. The plant is not sufficiently advanced as yet to test its merits, but, from appearances, it bids fair to be a success.

Ship building has been remarkably dull during the past year, but, while in our own country the question of building up our much needed navy is still largely an undecided question, the

European powers have been steadily improving their navies in every direction. Whole fleets of fast torpedo boats have been built, especially in England and France, and not only for themselves but also for other nations. Besides, some remarkably large vessels have been launched—especially in England—while several are in course of construction. Probably the most formidable man-of-war yet built is the English armored ram Ben Bow, which was launched at the Thames Iron Work and Ship Building Company on June 15th. In her construction over ten thousand (10,000) tons of metal have been used. She is built entirely of steel. Her armor plates, which are sixteen inches thick, are faced with six inches of chilled steel, and some of them weigh ten tons. The Ben Bow is three hundred and thirty feet long, and sixty-eight feet six inches beam, and thirty-seven feet deep, and has a displacement of ten thousand (10,000) tons. Her engines are nine thousand five hundred (9,500) horse-power, which will give her an estimated speed of seventeen and a half knots per hour. She will have two one hundred and ten ton guns of steel, which will fire a shot weighing two thousand pounds and sixteen and a quarter inches in diameter, while the charge will consist of nine hundred pounds of powder. She will have ten six inch rifled breech loading guns, ten six pound quick firing guns, ten four-barrel one inch machine guns, and four five-barrel .45 inch machine guns. She is also fitted for torpedoes, having five apertures for their discharge.

The Chicago, the last of the four cruisers built by John Roach, at Chester, Pennsylvania, has been launched and is being made ready for sea. It is said that these four vessels will rank as first-class naval vessels.

In England two armor clads are building of ten thousand four hundred and seventy (10,470) tons displacement, each with eight thousand five hundred (8,500) horse-power, to give a speed of fifteen and a half knots. The armament will consist of two one hundred and ten guns in the turret, ten six-inch breech loaders on upper deck, twelve quick firing guns, and twelve one-inch Nordenfeld's on the spar deck. The armor plating is to be eighteen inches on sides, sixteen inches on bulk-heads, eighteen inches on redoubt and turret and three inches on decks, with a

backing of six inch teak. They will be three hundred and forty feet long between perpendiculars, and the weight of hull will be six thousand eight hundred and fifty (6,850) tons. Four new belted cruisers are also building, each with a displacement of five thousand (5,000) tons. The hulls are steel throughout. They will be three hundred feet long by sixty feet wide. The engines will be seven thousand five hundred (7,500) horse-power, with forced draught and closed stoke hole. They will be armed with two eighteen ton guns, twelve four ton guns, six machine guns, and a torpedo equipment with above and below water discharge.

It is also stated that Spain has asked England for tenders for war ships to cost over fifty million dollars ($50,000,000), including four ships of ten thousand tons each, each to have two one hundred and ten ton guns, besides several ships of the Esmeralda type and forty torpedo cruisers.

The great dry dock built at Saint Johns, Newfoundland, by John E. Simpson & Co., and completed in December, 1884, has proved up to date to be all that was expected, and a monument to American skill and ingenuity. This dock is six hundred and ten feet and ten inches (610′ 10″) long on coping from head to outer gate sill, five hundred and sixty-nine feet and six inches (569′ 6″) long on floor from head to outer gate sill. One hundred and thirty-two feet and six inches (132′ 6″) of body on coping, forty-nine feet and ten inches (49′ 10″) width of body on floor, eighty-four feet and nine inches (84′ 9″) least width of entrance on coping and fifty-two feet and nine inches (52′ 9″) least width of entrance on floor. The greatest beam of floating gate or caisson is twenty feet and six inches (20′ 6″), making a total available length of dock on access, inside of gate at outer abutment on coping, six hundred and one feet and six inches (601′ 6″) and, on the floor, on top of two feet of keel blocking, five hundred and sixty-three feet (563′). The greatest depth of water over the inner gate sill is twenty-five feet. The dock is similar in shape and construction to the wooden graving docks in Brooklyn, Philadelphia and Baltimore.

In gunnery the same gigantic strides have been made towards increasing the range and initial velocity, as marks the progress

of the building of ironclads. The immense gun constructed at Ellswick for the British government has a trial weight of two hundred tons. Its length is forty-four feet; the extreme diameter at the breech five feet and six inches, the chase or barrel tapering down to twenty-eight inches at the muzzle.

The most formidable weapon heralded from Europe (according to the French journals) is the gun invented by Colonel de Bange, of France. The length of this gun is thirty-six feet and twenty-seven hundredths (36.27), and that of the chamber for the powder nine feet and one tenth (9.1). The rifling is in the same sections and directions as in the standard French guns, and the charge is three hundred and ninety-six (396) pounds of coarse grained powder. The projectiles are two in number, the one weighing nine hundred and ninety (990) and the other thirteen hundred and twenty (1320) pounds. The shot are three and ninety-three one-hundredths (3.93) of a foot in length, or three and one-half calibres. The gun carriage is so arranged that it commands a vertical range of from fifteen degrees below the horizon to thirty-three degrees above. It is said that the range is over twelve miles, and the initial velocity of the shot twenty-one hundred (2100) feet. The French claim for the field guns built on the Bange system a superiority over the German field guns, and the manufacturers are receiving large orders from different European nations for batteries of the same.

The Congressional Committee, appointed to investigate and report upon the policy to be adopted by our Government to secure a supply of ordnance and armor plate, met in New York, in November last. Many of the most prominent steel manufacturers were present at the meetings. From some of the facts developed at these meetings, namely, that the Cambria Works had three open hearth furnaces capable of casting an ingot large enough to make a one hundred ton gun, and also that there were rolling mills in this country capable of rolling armor plate of from nine to twelve inches in thickness, it is to be hoped that our government may, at an early date, awake from its torpor and move in the direction of building armored ships and guns worthy of this great nation.

The Midvale Company, of Philadelphia, furnishes the steel

forgings for the guns now under construction for the new cruisers, but although this fact gives some ground for encouragement, it still leaves a great deal to be desired.

Steel is now almost entirely superseding iron in the construction of ships; wires or bars are now produced directly from fluid steel by pressing it through dies, in a manner similar to the production of lead pipes from lead.

Professor Thomas Egleston, before the Convention of the American Society of Mechanical Engineers of New York, held in Boston, in November, read a very interesting paper on the Basic Bessemer Process. I need but quote his first few opening lines to convince you of the importance of this subject. Professor Egleston says:

> "In the year 1878, a paper on dephosphorizing iron was "presented to the Iron and Steel Institute of England, which "was considered to be of so little importance that it was "withdrawn by the authorities of the Institute before it was "read to that body. This paper was written by Messrs. "Thomas and Gilchrist, and was published as a part of the "Proceedings of the Institute by mistake in "Engineering." "Notwithstanding this reception of it, it was not long before "it began to attract the attention of the iron and steel manu-"facturers. This is the history of the introduction of what "proved to be the most important improvement in the "treatment of iron ores and pigs, which had before that "time been considered too impure for use. The amount of "output of steel made from material previously considered "unfit for use, in 1882, the fourth year after the introduction "of this improvement, was four hundred thousand tons, and "during the year 1885 will probably amount to over a mil-"lion tons."

The great mine under Flood Rock in New York Harbor, was fired on October 10th, and the work of nearly eleven years of rock excavation, and the roof left over miles of subterranean galleries, was shattered. The total mass of explosive used was two hundred and forty thousand (240,000) pounds of rackarock and forty thousand (40,000) pounds of No. 1 dynamite. The rackarock is a compound of chlorate of potash and dinitroben-

zole. Tests made by General Abbott with it, showed its strength to be nearly fifteen per cent. higher than No. 1 dynamite, taking this as one hundred.

About thirty thousand tons of broken rock require removal. The contractors have commenced work at this, at prices ranging from three dollars and nineteen cents to three dollars and ninety cents per ton, which is equal to from six dollars and thirty-eight cents to seven dollars and eighty cents per cubic yard,—a ton of this rock weighing about two cubic yards. At this price it is difficult to see where the economy of the system adopted at Flood Rock comes in, especially when the total cost per cubic yard is compared with the cost for the same character of work on the Clyde, where Colonel Beaumont's subaqueous drill is being used exclusively, making all allowances for difference in cost of material and labor.

The use of natural gas in and around Pittsburgh has very largely diminished the cost of production of iron, as well as of other materials, and bids fair to prove a conundrum to the manufacturing communities who have not the advantage of this boon. The question of manufacturing hydrogen gas for heating and lighting purposes is attracting daily more and more attention. Its utility and practicability were conclusively shown at the Franklin Institute Exhibition, which was held in this city last year. It is said that fuel gas can be used in iron works, rolling mills and glass factories at a saving of one-quarter of the former outlay for fuel. If this is so, manufacturers need not fear the competition of natural gas. In the manufacture of gas for city lighting, great improvements are made. Large gas works are in course of construction in Baltimore, on the same system as the Equitable of New York. The process used is what is called the Germanoski system,—steam, naphtha and lime being the agents from which this gas is manufactured. The company expects to furnish gas of thirty candle power at less than one dollar and fifty cents per thousand cubic feet.

At Desseronto, Canada, gas is used made from saw dust. This, of course, is not a new process, since it has been used—and especially in Norway and Sweden—many years ago. By a new arrangement of the mechanism, however, it has been made

possible to produce a first-class luminant. The residuum, consisting of charcoal, tar, pyroligneous acid and alcohol, command ready sales at remunerative prices. The cost of this gas is less than two cents per thousand cubic feet in the holder. Of course it can only be applied in places where sawdust is plentiful, and its first cost is really nothing, since the use of it actually removes a nuisance.

The electric light is fast superseding gas for illuminating purposes, and especially for lighting squares and streets, in cities, and wharves and docks. The application of it for the handling of freight, from and on to shipboard, is a vast improvement on the original system of using gas. Electricity has also been applied with more or less success for moving passenger cars on elevated railroads and on street passenger lines. The Daft electric motor, now in operation in Baltimore, although laboring under many disadvantages but few months ago, is now considered a success.

The question of supplying large and densely populated cities with an abundance of wholesome water for dietetic purposes, is one which is of all absorbing interest. New York is spending millions, and Brooklyn is preparing to spend vast sums on the extension of her water works system. Boston and Baltimore have spent many millions in this direction, and with apparently satisfactory results. In our own city it has become a matter of the greatest importance. The condition of our streets, sewers and bridges has been dwelt upon so often in our Club, that it is useless to attempt to point out any needs in these directions. We all know what is wanted. That our streets and sewers and water distribution can and should be improved, we all unanimously admit. The capital required to make Philadelphia what she should be, will undoubtedly demand serious efforts on the part of our citizens for some years to come, but meanwhile, since in accordance with the old adage—"we must row with the oars we have on hand"—are we doing our level best? If our streets are not as clean as they should be, although cleaner than those of most other large cities of the Union, can they not be made and kept cleaner? This is a question with which engineering probably has little to do, and yet, when we notice how street paving is

done, without regard to rise or slope or soundness of foundation, it strikes me that the intelligence and the watchfulness of the engineer might be usefully employed. The conditions of the mains for distributing the water supply is also one well known to be seriously defective, although much has been done within the last few years to improve its condition. We read, however, from time to time, about old mains that have been for years in the ground, and which are so filled with rust and sediment as to have become completely useless. I am not referring to Philadelphia especially, because this is heralded from almost every city where mains have been in use for many years. I know of nothing that is being generally done at present, to prevent mains laid in recent years from falling into the same state. I cannot help thinking, but that the cry of waste and prevention of waste is in many instances economy on the wrong side. The word waste is a very elastic one. The interpretation of it depends largely on the habits of the people. What is condemned as waste in one place is extolled as a necessity in the other. The cost of pumping water is withal a small one; the cost of relaying pipes or mains comparatively a large one, and a nuisance if required to be done in busy streets, and I think that forcing water under great pressure through the mains and into the sewers, and the regular opening of fire plugs would tend largely towards removing the sediment and keeping the mains clear many years longer than is generally the case. There should be positively no dead ends to mains, and the work of opening fire plugs should undoubtedly be attended to by the parties in charge of the water supply and not left in the hands of others, who can have but little interest in this work. Again, this work can and should be done in the night time, and especially in cold or wet seasons, when the demand for water is at its minimum. The laying of mains or pipes, whether for gas, water or for any other purposes, including the digging of trenches, should be done at night, although making joints should probably be done by daylight. The use of the electric light has made this perfectly feasible, and no one would deny that this would be a vast benefit to the daily traffic in the streets. Of course this speaks of night work, and night work is, alas, something to which city departments, as a

rule, are strangers. Watch the operations in private life, say of the railroad or a steamship company. The ship comes into port behind time; her sailing date is fixed. Does a private concern ask how many hours constitute a days work—or is the loss of time and opportunity made up by incessant work day and night? Is this not the principal reason why private concerns keep their work right up to the mark all the time? I think if this spirit were imbued into city departments in general, if there would be more earnestness and love of work, more of a desire to reach a state of perfection, if for self-satisfaction only, there would be more generally a marked change for the better all around.

The question of municipal engineering is one which should be intimately associated with the interests of our Club, and I offer the suggestion whether it would not be both profitable to ourselves and to the interests of the city, if the Club would make the engineering aspects of Philadelphia and its necessary improvements the most important subject for discussion during this and the years to come. I think that if but a half hour were devoted at each meeting to this subject, (and the various plans showing what we have in mains, sewers, highways and bridges no doubt could be readily obtained to be the property of the Club), I have no doubt but that with so many minds all eager to advance the City's interests, much could be suggested which, if unanimously endorsed by the Resident Members of the Club, would be of vast interest to the welfare of the City, while at the same time useful to the members.

Before surrendering the chair to my worthy successor, I desire to thank you all for the uniform kindness and forbearance which you have invariably shown me, and to express my heartiest wishes for your continued happiness and welfare, whilst I beg you to accept the assurance on my part that the interests and the prosperity of the Club will ever be the object of my sincere interest.

OPENING ADDRESS

OF

WASHINGTON JONES, President.

ON TAKING THE CHAIR FOR 1886.

Presented January 9th, 1886.

FELLOW-MEMBERS:—I am quite sensible of the honor conferred by the vote announcing me as the presiding officer of the Club; but, I will say frankly, my own preference would have been that your selection had fallen upon some member whose association with you is of longer duration than mine. However, I feel sure that none can be more desirous than I am of promoting the interests of the Club, and of assisting to maintain its reputation and the respect with which it is regarded by kindred societies. I beg you will excuse me from extending my address, as I am not given to much speaking, having long entertained the belief that Engineers are known and esteemed by their works, rather than by their words.

I ask your co-operation in the discharge of the duties entrusted to me, and your indulgent consideration if I should fail to meet the requirements of the position which has been so acceptably filled by my predecessors.

XIV.

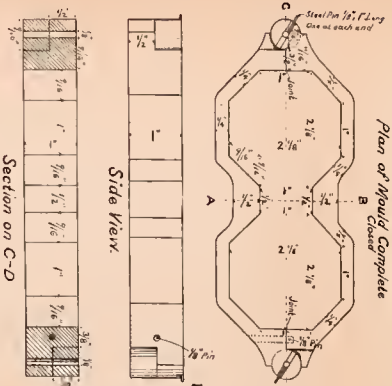
A NOVEL CEMENT TESTING MACHINE.

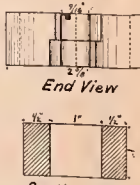
By P. F. BRENDLINGER, Active Member of the Club.

Read October 17th, 1885.

FOR want of a better name, I call it "novel"—perhaps "cheap" would have expressed it better, but then the manufacturers of testing machines would have made the same claim, viz.: that their machines are all cheap; so let it stay "*Novel.*"

I wish to state that I will not even claim equality with cement testing machines made by regular manufacturers, nor will I enter



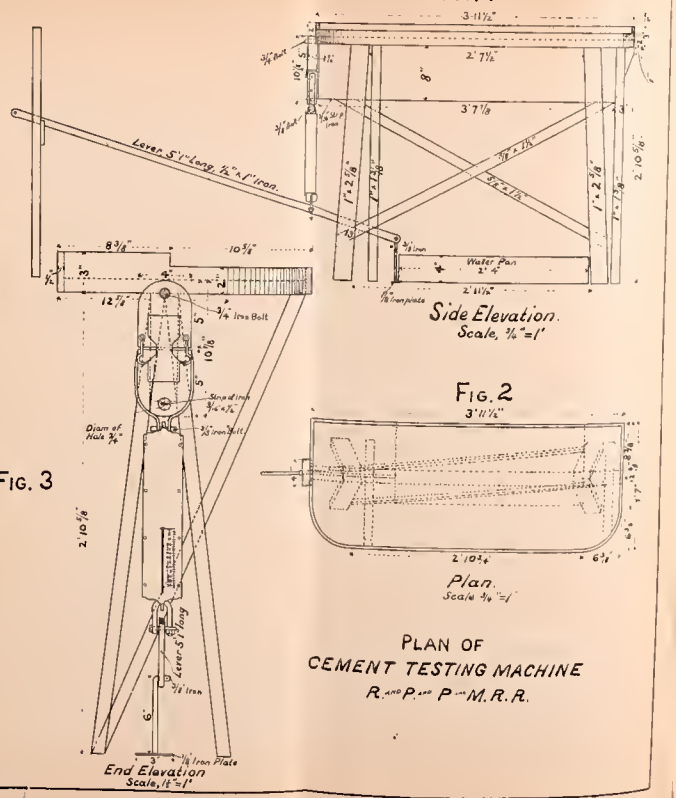


PLAN OF CEMENT BRIQUETTE MOULD

to be made of brass, filed smooth on inside and on top and bottom. Section at A-B to be one square inch exactly.

R. & P. R.R. and P. & M. R.R.

1/4 Size



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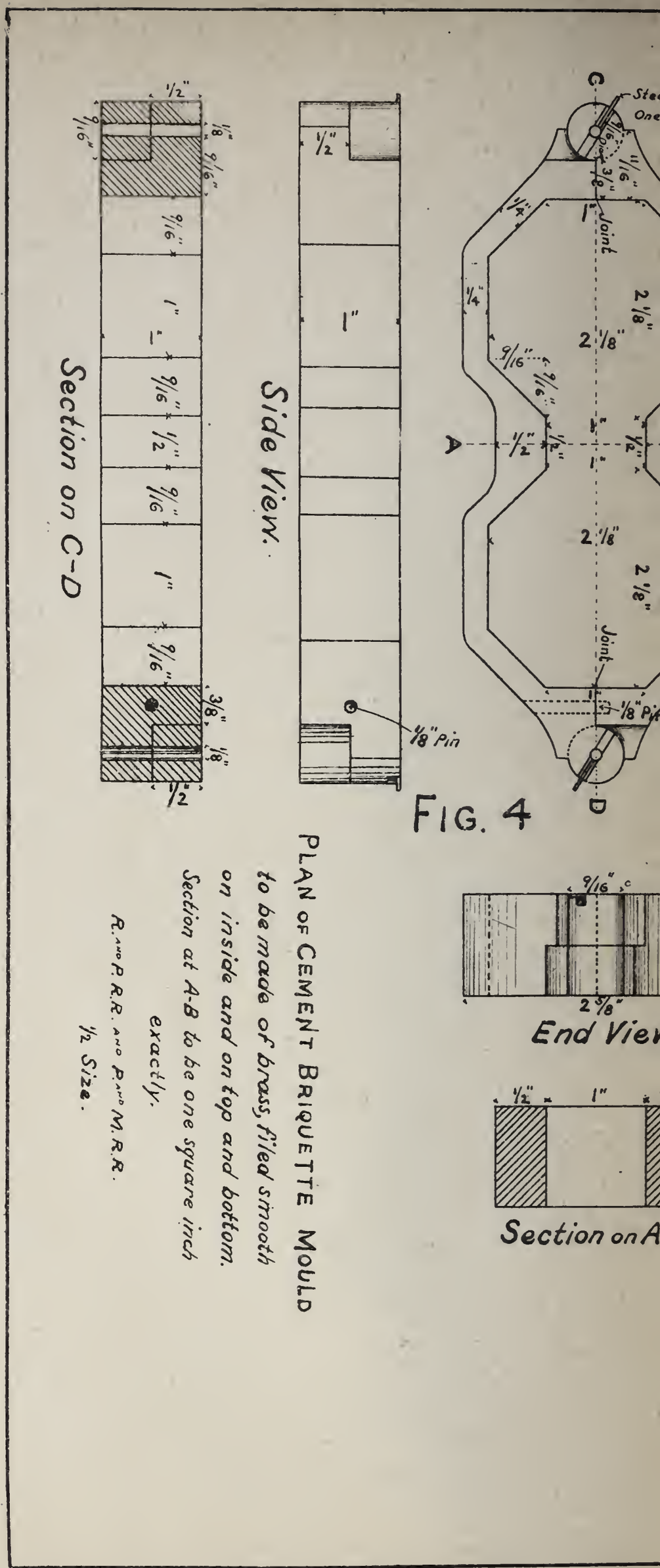


FIG. 4

PLAN OF CEMENT BRIQUETTE MOULD
to be made of brass, filed smooth on inside and on top and bottom. Section at A-B to be one square inch exactly.
R. and P. R.R. and P. and M. R.R.
1/2 Size.

upon the question of how to make cement tests, preparing the briquetts, etc. What I desire to produce is a machine that will test with sufficiently approximate accuracy to be used by all those engineers, contractors, and railroad men in general, who will not, or cannot afford to, buy standard machines, costing about $100. It is a very rare occurrence to see a cement testing machine on a railroad, in fact, not one road that I was ever connected with had a machine.

Immediately after commencing the construction of the Reading and Pottsville Railroad (last spring), cement manufacturers poured into my office, at Pottsville, with their wares; as usual, each manufacturer had the best brand, and backed up his statements with innumerable testimonials and tabulated statements, showing very fine results. I used some of these cements for a month, and by various crude tests satisfied myself, I was getting a variable cement, some good and some bad. My Prin. Asst. Eng., Mr. Chas. S. Churchill, and I then put our ideas together to construct a cheap testing machine, and the result is what I show by photograph and detailed plan of machine. The photograph shows the machine in working order with all the paraphernalia attached, as it stands in my office. In the detailed plan (Fig. 1) is a side elevation of the machine. The framework consists of an ordinary trestle I found lying around. An ordinary carpenter put on the top or table and made the wooden clamp at the end to hold the briquetts. The upper clamp is made entirely of oak, while the lower is bound with a strap of iron, and holding the spring balance reaching 100 lbs., a lever, 5′ 1″ long, is attached to the lower clamp and is kept from moving laterally by a vertical slit used as a guide in a board near the end of the lever; this insures a square break of the briquett. A small button holds up the lever when not in use. The upper clamp has two brass hooks, which catch in two eyes on the lower clamp, which hold the clamp together while putting in the briquett; then they are uncoupled, and the briquett is broken by means of the lever, etc. The lower clamp has a hole bored through it, into which an iron rod extends fastened to the trestle; this is for the purpose of stopping the fall of the lower clamp and balance after the briquett is broken. There is sufficient play around this bolt, so that no part

touches while the strain is applied. The water pan is shown under the machine and is made of galvanized iron.

Fig. 2 shows the plan of the machine. Fig 3 an end elevation on large scale, and Fig. 4 shows half size of briquett moulds.

The entire cost of this machine as built is $12, and by a few changes, the cost can be very much reduced; and on roads, where carpenters and blacksmiths are constantly employed and paid for by the month, a machine can be turned out some rainy day that will not cost over five or six dollars.

To obtain the exact breaking strain of a briquett, the number of pounds is read on the balance, and four pounds added for the weight of the lower clamp and balance. The briquetts are made in two ways: one of pure cement and immersed in water in the pan, and kept there for 24 hours, when they are broken; the other, a mixture of two parts sand and one part cement, kept immersed for seven days, then broken. This machine will not show as high results as are obtained from Riehlé's or Fairbanks' machines; but the comparative results between different cements can be just as readily obtained, and when a certain brand is once adopted, the uniformity of the cement can be just as well determined as in a better machine.

There have been over 600 tests made this season in this machine, and I know it would surprise many engineers to look over the pages of the record and see how bad some cement is. I would be glad to see every engineer, and purchaser of cement, use a cement testing machine, and wherever the cost has been in the way, it is now removed. Manufacturers of cement will not exert themselves very much to improve their cements, while they can sell more of the kind they have got, than they can make. But engineers can soon have a good article produced all the time after they have a testing machine.

I might add that a better and perhaps higher breaking strain can be reached by suspending from the end of the lever, a bucket, and having a hopper above it, filled with sand or shot, which would run into the pan, and thus put the strain on the briquett gradually. A number of changes could be made to suit the individual as long as the result is reached.

XV.

THE ADAPTATION OF STEEL TO STRUCTURAL WORK.

By James Christie, Active Member of the Club.

Read November 7th, 1885.

Though the use of steel in engineering structures is now widely extended, yet it has not attained the development that was ardently anticipated by many engineers a few years ago. The price of steel has now fallen so low as compared with that of iron, that its adoption will undoubtedly be actively stimulated, as soon as a revival of industry, especially of ship building, will offer a more extended market for the product of the mills.

The grades and properties of the steels are so various and distinct, and the special adaptability of each grade for a definite purpose, is so uncertainly understood, that opinions on the whole subject diverge widely.

Regarding the method of manufacture of structural steel, engineers have been generally favorable to the product of the open-hearth furnace, especially for mild steel of high ductility.

But recent results obtained from Bessemer steel show that it can be produced as uniform and reliable as its competitor.

From Bessemer ingots recently made for the Susquehanna Bridge, only 18 in a total of 120 tests, or 15 per cent., were rejected as not within the specifications.

Two years ago, of open-hearth steel made for the Niagara Cantilever Bridge, out of 245 tests 136 were rejected, or 55 per cent. of the total, for non-conformity to specifications.

A modification of the pneumatic system, known as the Clapp-Griffith process, is coming extensively in use—no less than five separate plants being under construction east of the Alleghanies alone.

The essential differences between this process and the usual Bessemer method, consist in the use of a fixed converting vessel with a cinder overflow, and the introduction of the air blast, under a more moderate pressure through the sides, instead of through the bottom of the converter.

Its advocates claim the ability to produce a mild steel having physical properties, which render it especially suitable for structural work.

The seeming tendency amongst American engineers at present, is not to specify how the steel shall be made, but simply what its physical properties shall be.

For boiler and ship plates, the common verdict is expressed in favor of the softest and most ductile steel that can be made, say 60,000 lbs. tenacity, elongation 25 per cent. in 8 inches, having no apparent hardening property, and capable of being readily welded.

For angles and beams in ship frames and decks, steel as high as 75,000 lbs. tensile strength is used, with definite limitation of the hardening qualities, and unimpaired capacity for welding.

For bridges, the line is drawn sharply between steel for compression and for tension members, or for members subject to alternate stresses of tension and compression.

Considering the shock, the impact or sudden reversal of stress, resulting from rapidly moving loads, bridge engineers should insist on high ductility for tension steel, and allow a high factor of safety for same when proportioning the structure.

For members subject to compression alone, such marked advantages occur from the use of high tension steel, that it may be best to sacrifice a little ductility for the sake of high resistance.

This is probably safe practice, for while a tension bar is liable to destruction—from a sudden snap, a column of either wrought iron or steel, if properly designed, is not equally liable to abrupt failure.

Many bridge struts have weak joints, or insufficient care has been exercised to carry the line of stress to the axis of the strut, but these and similar defects should be avoided, and if properly constructed, an overtaxed strut should exhibit its weakness by visible distortion before utter destruction occurred.

For tension members of bridges, recent specifications require an ultimate tenacity of 65,000 to 75,000 lbs. per square inch, elastic limit 40,000 to 45,000 lbs., and an ultimate elongation of 20 to 25 per cent. in eight inches. Sometimes a bending test, after cooling in water from red heat, is required to prove the absence of undue hardness.

For compression members, the tenacity is specified at from 80,000 to 90,000 lbs., and elastic limit 50,000 to 55,000 lbs. per square inch, elongation 18 to 20 per cent. in eight inches.

In the remarkable structure now under construction across the Firth of Forth, in Scotland, about 45,000 tons of open-hearth steel will be used. The engineers specify for tension members, a tenacity of 66,000 to 72,000, and elongation of 20 per cent., for compression steel 75,000 to 82,000 lbs. per square inch, and elongation of 17 per cent. in eight inches. Mr. Baker claims an undoubted advantage in the use of the high tension steel for compression members, although his hardest metal is soft as compared to the average rail steel, which ranges from 85,000 to 100,000 lbs. tensile strength.

In the Forth Bridge about one-half of the material has to sustain compression, therefore the selection of the best material was a subject of vast importance.

Judging from the compression experiments that have been made on the different metals, their relative compression resistances in lbs. per square inch of section, would be as follows:—for iron, for steel of 65,000 lbs. tenacity, and for steel of 90,000 lbs. tenacity:

Ratio of diameter to length.	Iron.	Mild Steel.	Hard Steel.
10	43,000	51,000	74,000
20	36,000	42,000	58,000
30	31,000	36,000	49,000
40	26,000	30,000	40,000

Columns longer than 40 diameters are unusual in bridges, but even at that ratio the high tension steel possesses an advantage of fifty per cent. over iron.

In the foregoing statement it is presumed that either material will sustain the same measure of resistance in built-up members that have passed through the usual ordeal of construction, that it has been proved able to endure in untreated bars, or that it has sustained in isolated experiments on finished columns. Herein lies the uncertainty, for, unfortunately, some experiments have betrayed a weakness on the part of the steel, which must be traced either to improper material, or else to faulty methods of manufacture.

On the Forth Bridge the engineers have been compelled to abandon the shearing process on plates; and the punch and the shears, hitherto the standard tools of the bridge-shop and the ship-yard, are replaced by the drill press and the planing machine.

If this change should prove to be necessary, it indicates that the methods usual in iron construction must be abandoned if we use steel, and a reorganization of existing finishing plants must take place—probably also a change in the design of constructive details will follow to suit the altered conditions. But such changes involve more expensive workmanship—and under the pressure of close competition, manufacturers will naturally cling to the cheaper methods, unless compelled to adopt the more expensive system.

In a limited series of experiments recently made under my direction, of small struts of both hard and mild steel—which were punched, straightened and riveted in the manner usual with iron—every piece sustained the normal pressure, and failed precisely as previous experiment indicated failure should occur with the component bars in the condition they left the rolls.

But when designing structures, the elasticity of the metal must be considered, and it is well known that in this respect wrought iron and steel stand practically on equality. Hence if we reduce the quantity of steel in a girder below the sections we should use if built of iron, we must expect greater deflection in the former than in the latter structure. This sacrifice of stiffness cannot always be allowed, and the result may prove that engineers will be compelled to use equal quantities of either material, trusting to the advantage gained in increased strength by the use of steel.

Steel as a structural material is still in its infancy, but it is evident that in its adoption we must exercise a degree of intelligent and vigilant inspection during all stages of its manufacture, that we have never accorded to iron.

To the intelligent engineer, this result would be an advantage rather than otherwise, as it would tend to abolish hap-hazard methods in both design and construction, and thus elevate and dignify his profession.

Steel Castings.

Steel castings are now being extensively used, and they serve an excellent purpose, especially for the machinist, as they admit of constructions for which either iron castings or forgings were unfitted. The metal is produced by all the usual methods, *viz.:* from the crucible, the open-hearth furnace, and the Bessemer converter. During the past year, the price has been appreciably reduced, and at the same time the quality improved.

The evil of sponginess, hitherto the bane of steel castings, is still an occasional fault, but the difficulty has been much abated by proper selection of metals, and improvements in foundry practice. When solid, the castings have nearly the same specific gravity, tenacity and elasticity nearly equal to, and ductility somewhat inferior to forged steel of the same grade. The castings are perfectly trustworthy under tensile working stresses of 10,000 to 15,000 lbs. per square inch of section, or about twenty per cent. better than iron forgings, or four-fold better than ordinary castings.

In at least one instance under my observation—that of a portable compression riveter—the transverse stress on the frame of the machine causes an intermittent tensile stress on the steel casting of 15,000 lbs. per square inch, and occasionally rising to 20,000 lbs., without apparent evidence of weakness. I have found steel castings unsuited to wear on each other in frictional contact. The surfaces interlock and cut under very moderate pressures. If one or both of the surfaces are hardened, this difficulty ceases, or steel castings may be run on surfaces of cast iron with satisfaction.

DISCUSSION.

November 21st, 1885.

Mr. Thomas M. Cleemann thought the use of steel instead of iron by engineers was dependent principally on the manufacturers producing a perfectly uniform and reliable product, which at present they do not seem to do. He thought that the advantage of using a cast metal was in favor of steel, by which struts could be made of a hollow circular section, requiring least mate-

rial, and the punching of holes for fastening pieces together by riveting, which especially weakens steel of a high grade, could be dispensed with.

Mr. James Christie said in reply, that it was very improbable that struts would ever again be made directly from castings. Aside from the difficulty of maintaining a uniform thickness of metal, the cost of construction would be greater than by the present method of building up rolled material.

Prof. Wm. H. Burr said the steel question presents itself to engineers under two entirely different aspects. The first involves the character of the metal *per se;* and the second is based upon the consideration of the influence of this metal on structural design. In the first place, although improvements in the uniformity of production can yet be made, steel makers, by either the Bessemer or open hearth processes, are ready to work under any physical specifications affecting uniformity that may be demanded by the best engineering practice of the present time; and it may be safely asserted that increased uniformity will keep pace with any demand.

Unfortunately, however, there seems to be considerable diversity in the results of experiences with the many and varied shop manipulations necessary to the completion of the structural member. Mr. Christie tells us that in supplementing his most admirable tests on angle iron struts, by those on composite riveted columns, he found the ultimate unit of stress in the latter essentially equivalent to that realized in the former. On the other hand, I am credibly informed by the chief inspector of an extensive railway system, that some full sized high Bessemer steel latticed columns built for a large bridge failed, when tested to destruction, to give much, if any, excess over corresponding wrought iron columns. These and other similar results suggest the possibility, or even probability, that the known sensitiveness of high steel demands a more extensive experimental experience with finished bridge members before the general use of such metal in columns can be considered satisfactory. Low structural steel of 60,000 to 65,000 lbs. ultimate tensile resistance, is capable of any

duty in the finished structure in the most satisfactory manner, and high steel of 80,000 to 90,000 lbs. ultimate tensile resistance will eventually be equally reliable, but there are serious reasons for much care in its present use. The effect of the introduction of steel on structural design has not yet received the same consideration as that of constructive processes. With the increased working stresses allowed in steel, the coefficient of elasticity remains essentially the same as for wrought iron, with its lower allowable stresses. With the same design in both metals, the result is an increase of strains for steel in direct proportion to the unit stresses, and precisely the same proportional increase of deflections. The present and increasing requirements for rapidly moving loads make this a very serious aspect of the question, and give rise to a corresponding modification of design, so that proper stiffness as well as strength may be maintained. A comparison of the deflections of the Niagara and St. John's cantilevers, shows very clearly the effect of a constant coefficient of elasticity with an increased working stress. The principal dimensions of these structures are sufficiently near in value to afford a very interesting comparison. The greatest deflection of the Niagara Bridge, with its high steel compression members, with working stresses that cannot be far from 9,000 to 10,000 lbs., in combination with wrought iron tension members, was $7\frac{5}{16}$ inches; while that of the St. John's Bridge, with all members of about 60,000 lbs. steel and corresponding working stresses, was 4 inches. A proper allowance for the compression of the steel piers of the former leaves a remaining difference of over 2 inches. Again, the effect of alternate stresses of opposite kinds on the design of steel members, is still a matter in almost a purely conventional state. The experiments of Weyrauch and Spangenberg are of the right kind, and constitute a long step in the right direction; but it must be borne in mind that these experimenters treated specimens and not structural members. The ultimate physical condition of steel furnishes strong reasons for believing that its fatigue under compression will be considerably less than that of wrought iron.

XVI.

RECENT SPECIFICATIONS AS AFFECTING THE DIMENSIONS OF IRON R. R. BRIDGES.

By J. S. Elliott, Active Member of the Club.

Read November 21*st*, 1885.

Based as engineering methods are on an exact science supplemented by the experimental research of years, it is nevertheless often the case that the members of our fraternity find themselves in positions where silence is very good gold as far as the prophesying of results is concerned. Certain as they may be of the purely mathematical treatment, the suspicion of some illogical assumption, together with the disagreeable consciousness of the insufficiency of existing data, is enough to make them suspect that they are experimentalists on a large and costly scale, where, if success means professional honors, defeat as certainly entails hopeless notoriety.

It is this figuring about what we do not know plus a few failures that has caused the rabidly "practical man" to look somewhat askance at his scientific brother, and that tends to strengthen in a melancholy way the old joke that the stability of a structure is invariably inversely as the scientific acquirements of the builder.

Wherever a shaft of this kind may lodge, it certainly loses its point altogether, or at any rate, becomes blunted when directed against American iron bridge building. Incomplete, as are still our data and experiments, this branch of our profession can lay claim to a closer harmony between theory and practice than any other. We roll iron to any reasonable required strength; can estimate the weight of a contemplated structure to within a few pounds; the developed strains are what they are calculated to be, and act along their assigned lines.

In short, such is the simplicity of design of our best types, and so close is the agreement in essentials among our bridge designers, that any criticism of prevailing methods would be ignored if of a denunciatory tone.

My endeavors here are to show to what extent variations in our later standard specifications affect the bridge-member dimensions,

and to point out any inconsistencies or unnecessary refinements in those specifications.

That different requirements cause great differences in the amount of iron, there can be no doubt. Among the bridges recently built by the Detroit Bridge and Iron Co. Works, are the three following, all single track:

		Iron Weights.
1—162′ Through Span for the Wabash Railway,		178,089 lbs.
1—164′ Deck " " " " "		206,356 "
1—154′ Through " " "	L. S. & M. S. Ry.	230,230 "

The third span here is 8 ft. shorter than the first, and yet has 30 per cent. more iron in it. Such differences, however, are rare and are the results largely of unequal live load requirements. These have lately increased very much.

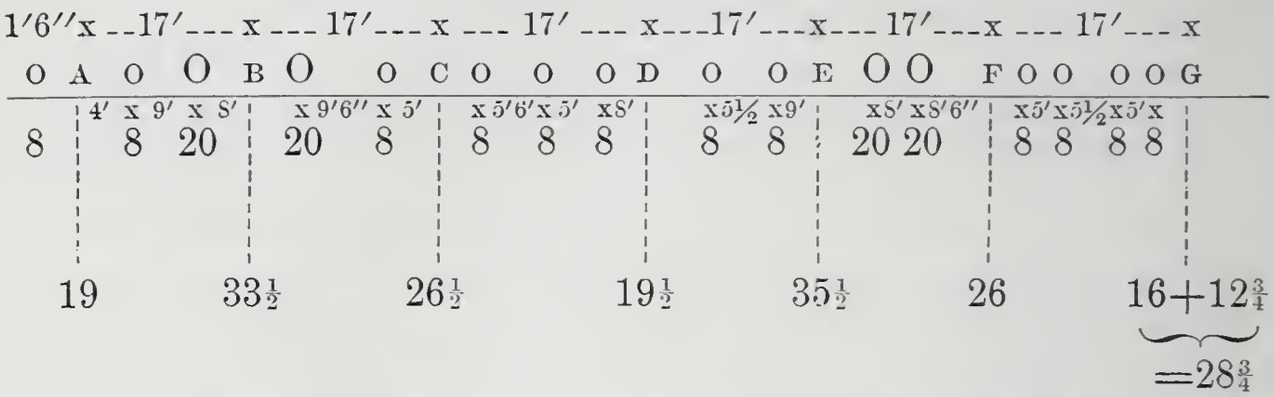
The general specifications for Cincinnati Southern R. R. bridges, in 1875, give "two locomotives coupled, each weighing 36 tons on drivers, in a space of 12 ft.; total weight of each engine and tender loaded, 66 tons in a space of 50 ft., and followed by loaded cars weighing 20 tons each, in a space of 22 ft." To-day the Phœnix Bridge Co. provides for a uniform load of 3000 lbs. per foot, headed by two consolidation locomotives, each weighing 171,000 lbs., with 96,000 lbs. on the four pairs of drivers, 14′ 9″ wheel base. The additional 1000 lbs. in train load is no provision for any future increase in rolling stock, for a P. & R. R. R. coal car, 24′ 1½″ long, already weighs 78,000 lbs., or some 3,200 lbs. per lin. ft.

Formerly, for purposes of calculation, the train load was considered uniform, and the excess in each set of locomotive drivers was concentrated at the head of the locomotive. Concerning this, the last album of the Phœnix Bridge Co. says:

"The old method of a uniform moving load with locomotive excess in front, no longer meets the requirements of the best structural designs. The wheel concentrations must be taken as they are, and that position assumed which will give the greatest value to the stresses sought. These observations possess special force in connection with the design of floor-systems of railway bridges."

For the floor-system, this is perfectly right; but for purposes of

getting the web and flange strains, it seems to me an unnecessary refinement. The annexed diagram shows the actual load distribution for two passenger locomotives in order to get the maximum flange and web strains in a truss with a panel width equal to 17 ft., *c* to *c*.



Each locomotive with tender weighs 88 tons, and has 40 tons concentrated on two pairs of drivers, 8 ft., *c* to *c*. Six panels, each 17 ft. long, are thus covered, and the loads at the lettered panel joints vary from what they would be, assuming a uniform load equal to 3000 lbs. per lin. ft., to this extent: $A = -6\frac{1}{2}$ tons, $B = +8$ tons, $C = +1$ ton, $D = -6$ tons, $E = +10$ tons, $F = +\frac{1}{2}$ ton, $G = +3\frac{1}{4}$ tons. As these variations in joints *A*, *C*, *D*, *F* and *G* are none of them very large, I assume a uniform panel load, $25\frac{1}{2}$ tons at each joint, except at *B* and *E*, where is placed besides an excess = to 9 tons. The strains in the web members of a Pratt truss, length of panel, 17′ *c* to *c*, calculated by these two methods, varied no more than 5 per cent.—the error in using the easier method being one on the safe side. In fact, the assumption of a very heavy train load diminishes the amount of the locomotive excess, and the inspection of the diagram will show that these same strains would alter, in this particular case, but little assuming a uniform load, and abolishing the said excess altogether. In figuring the strains in bridges, it has always been the custom to assume that the loads acted at the loaded flange joints. Some recent specifications make this provision:

"In addition to the live loads before mentioned, the structure shall carry the following dead load, viz.:

At the panel points of the loaded chords,

First.—The weight of the floor (composed of the weight of the cross ties used for the particular kind of floor adopted, and a

weight of 140 lbs. per foot lineal of track, covering the weight of rails, guard rails, splices, spikes, and bolts).

Second.—One-half the weight of the truss.

Third.—The weight of the iron floor system, if any.

Fourth.—The weight of the lateral system belonging to the loaded chord; and

Fifth.—One-half the weight of the sway bracing.

At the panel points of the unloaded chords:

First.—One-half the weight of the truss.

Second.—The weight of the lateral system belonging to the unloaded chord, and

Third.—One-half the weight of the sway bracing."

It is not easy to see the advantage of leaving the old custom here. The flange strains of a Platt or Howe truss are not thereby altered, and indeed the sole change would be a plus or minus variation in the posts equal to the panel load of one unloaded chord. About 28 per cent. of the static load goes to these unloaded flange joints; this is such a small percentage of the accumulated stresses brought on Pratt posts that it could as safely be left out.

The stress laid on wind bracing is one of the strong points in American methods. The custom now is to proportion the loaded flange lateral bracing for 450 pounds per lineal foot—300 pounds of which to be considered as a moving load; to the bracing of the unloaded flange are given 150 pounds per lineal foot. Also, no addition to the flange sections due to wind strains shall be made as long as the wind strains are within one-quarter of the maximum strain due to dead and live load, and as long as the wind strains alone, or in combination with a possible temperature strain, cannot neutralize or reverse the tension in the end panels of the lower chord. Such are Mr. Theodore Cooper's provisions in his last specifications; the first portion slightly modified is also insisted upon by Messrs. Wilson Bros., members of the Club, in their last album. This involves an important principle—a sound one, that might have a more extended application, for, it asserts it to be so seldom the case all possible attacking forces are combined, that it is not thought worth while to provide for such a contingency by increasing the chord section as long as the attack

fails to reach certain proportions. Granting this, why not apply it for purposes of economy to a double track through Pratt span where each truss is but very seldom strained to the full extent of its allowable stresses—in fact, to hardly more than three-fourths of what is permissible?

Would it not, therefore, be consistent and sound to use somewhat larger unit stresses—say 12,000 and 9,000 pounds for tensile and compressive units, in such a case, rather than the generally accepted values, 19,000 and 8,000 pounds? Between 15 and 20 per cent. of metal would thereby be saved.

To Germans and Americans belongs the credit of first making the maximum allowable unit stress a variable quantity—a function of the quality as well as quantity of loading. With us, it was common sense that told us to make an allowance for stresses alternating in character, such as withstand the braces of any Warren girder. The Germans took measures to formulate their opinions by experimental aid. These experiments, with subsequent deductions, are well known to all bridge engineers, but as there may be some members present whose specialties do not include bridge matters, I will do more than merely allude to them. The foundation of the new method is Wöhler's law itself, based on experiment. We will suppose a bar subject to a repetition of stresses alternating in quantity.

It maintains that rupture may not only be produced by applying the ultimate strength of the material once, but also by using a smaller stress, provided the application is repeated often enough. The larger the number of repetitions, and the greater the difference betwen the alternating stresses, the smaller this rupture stress becomes, and *vice versa*.

Furthermore, for each material there is a limit of stress, V, for which an infinite number of stress repetitions, alternating with a complete release from stress, will not produce rupture. From this law and his "inner consciousness," no contemptible ally to a German, Launhardt derived his formula for finding the safe working strength (a), which, simplified for wrought iron, is used by the Messrs. Wilson, as follows:

$$a = u\left(1 + \frac{\text{minimum stress in member}}{\text{maximum stress in member}}\right)$$

$$a = \text{permissible stress per square inch}$$

$$u = \frac{V}{\text{some factor of safety}} = 6500 \text{ or } 7500 \text{ lbs. per square inch,}$$

depending on the shapes used.

To the best of my belief, these gentlemen were the first in this country to apply Wöhler's law rationally. Dr. Weyrauch, of Stuttgart, followed in Launhardt's footsteps, and derived from the same law a formula applicable to stresses of two kinds (tension and compression). Logical as his formula is, it still lacks the experimental confirmation of Launhardt's.

Though, of course, the Germans carry off the palm, due praise should be given to the Americans for instinctively modifying their units, so as to conform in a rude way with the new method. The Engineer of the Forth Bridge, Mr. Baker, in a late address before the British Association, recognizes this, saying:

"Leading Continental and American engineers have asked me what is my practice as regards the admissible intensity of stress in iron and steel bridges, and in replying I have invited similar communications. At the present time engineers have not come to any agreement on this point. The variance in the strength of existing bridges is apparent without any calculation. Nearly all the large railway companies are strengthening their bridges, for cases exist where the working stress on the iron has exceeded by 250 per cent. that considered admissible by leading American and German bridge builders." * * * * * * * * * "A bridge which would be passed by the English Board of Trade would require to be strengthened 5 per cent. in some parts, and 60 per cent. in others, before it would be accepted by the German government, or by any of the leading railway companies in America.

"This undesirable state of affairs is caused by many engineers still persistently ignoring the fact that a bar of iron may be broken either by the single application of a heavy stress, or by the repeated application of a comparatively light stress."

Speaking of Wöhler's law, he goes on:

"Wöhler first attempted to determine the laws governing the already proved destructive action of intermittent stresses. In previous experiments the bar or girder was alternately fully loaded and wholly relieved of load. Wöhler tested also the result

of a partial relief of load. The striking fact was soon evidenced in testing specimens under varying tensions, that the amount of the variation was as necessary to be considered as that of the maximum stress. Thus, an iron bar having a tensile strength of 24 tons per square inch, broke with about 100,000 applications of a stress varying from nil to 21 tons, but resisted 4,000,000 applications of the 21 tons when the minimum stress was varied from nil to 11½ tons. The alternations of stress in the case of some test pieces numbered no less than 132,000,000. These experiments proved that any bar or beam of cast iron, wrought iron, or steel, may be fractured by the continued repetition of comparatively small stresses, and that as the differences of stress increase, the maximum stress capable of being sustained diminishes."

"Various formulas based upon the preceding experiments have been proposed for the determination of the proper sectional area of the members of metallic structures."

"Many engineers consider that the admissible stress per square inch in a wrought iron girder, subject to a steady dead load, would be one and a half times as great as that in a girder subject to a wholly live load, and three times that allowable in members subject to alternate tensile and compressive stresses of equal intensity, such as the piston-rod of a steam engine, or the central web bracing of a lattice girder. If the alternations of stress to be guarded against are not assumably infinite in number, but only occasional—as in wind bracing for hurricane pressures, or in a vessel during exceptionally high waves—then the aforesaid ratio of 3, 2, and 1 would not apply, but would more nearly approach the ratios 6, 5, and 4.

"Hundreds of existing railway bridges, which carry 20 trains a day with perfect safety, would break down quickly under 20 trains per hour. This fact was forced on my attention nearly twenty years ago by the fracture of a number of iron girders of ordinary strength under a five minute train service. Similarly, when in New York last year, I noticed, in the case of some girders on the elevated railway, that the alternate thrust and pull on the central diagonals from trains passing every two or three minutes, had developed weaknesses which necessitated the bars being replaced by stronger ones after a very short service."

As far as the purses of bridge buyers are concerned, the new rule means increased expenditure for light, and a saving in long heavy spans, for simple inspection shows us that the permissible stress varies as a function of the ratio of dead to total load. The limits are 6500 and 7500 lbs. and double these quantities—the first to be used when there is no dead loading, the last when there is no live loading.

Take, for example, a bottom flange member in the wrought iron 400′ span of the Bismarck Bridge, which, according to the specifications, should have a maximum stress of 10,000 lbs. per square inch, but as a matter of fact has 10,850 lbs. The dead and total stresses are 191,600 and 358,000 lbs.—the new rule makes $a = 7500 \left(1 + \frac{191600}{358000}\right) = 11{,}510$ lbs., a saving over the first as 10,850 is to 11,510. Mr. Theodore Cooper, C.E., specifies 10,000 for such tension members, but adds that for spans exceeding 150 feet an increase of stress may be added by a percentage $= \left(\frac{150 \times \text{dead load strain}}{\text{Total max. strain}} - 50\right)$. According to this, therefore, we can strain the flange as high as 13,000 lbs. per square inch, an excess of 20 per cent. over what Mr. Morison, Engineer of the Bismarck Bridge, thought permissible.

Striking as this difference is, an application to the 520-foot span in the C. S. R. R. gives still more reason for reflection. This span was designed to stand a rolling load = to 2000 lbs. per lin. ft.; its dead load is some 5500 lbs. "A" for all bottom flanges $= 7500 \left(1 + \frac{5500}{7500}\right) = 13{,}000$ lbs. per square inch. As the actual specifications limit tensile stresses to 10,000 lbs. per square inch, the bottom flange, according to new methods, could have been made 30 per cent. lighter, without endangering the safety of the structure, and nearly the same proportion would hold good for all other parts of this truss. By Mr. Cooper's method, our unit stress would be $10{,}000 + \left(\frac{150 \times 5500}{7500} - 50\right)$ per cent. $= 16{,}000$ lbs., making the flanges 60 per cent. lighter than they are. It is hard to think that Mr. Cooper would sanction such an unit — $\frac{2}{3}$ of the elastic limit, especially as his formula is an arbitrary one.

These few applications are enough to show how badly we need additional experiments on a large scale, for Wöhler by no means drained the well of truth dry.

XVII.

THE BEHAVIOR OF TWO BRICK ARCHES.

By J. Foster Crowell, Active Member of the Club.

Read November 21st, 1885.

The correct proportioning of an elementary arch in masonry, involving only simple static principles and the character of material, should not, and generally does not, present difficulties to the engineer; even the neophyte feels more at home in this field than in many others, and is quite ready when occasion offers to proceed with confidence. The data from noteworthy examples are readily obtainable, and there is no lack in the literature of the subject. But notwithstanding the comparative ease and certainty with which the design can be prepared, its fulfilment in the completed structure, is often far from satisfactory.

Not to refer to actual failure (and we need not allow our thoughts to roam very far to recall such instances), partial crippling, deformation that offends the eye, and perhaps arouses apprehension, an unsightly crack, uneven settlement, one or all often mar the effect of strength and symmetry which the designer sought to produce.

The function of the engineer is not generally limited to the design; the construction and the finishing of the work should be his also, and it therefore is essential to his success in work of the character under discussion that he should consider well the building of the arch, and that the successive steps in its progress should be intelligently directed and not entrusted in its detail, either to the contractor, who is unfortunately too often more concerned with the percentage of profit than to the perfection of his masonry, or to the average inspector who, though generally faithful and honest, is seldom competent to deal with the weightier matters of the physical law.

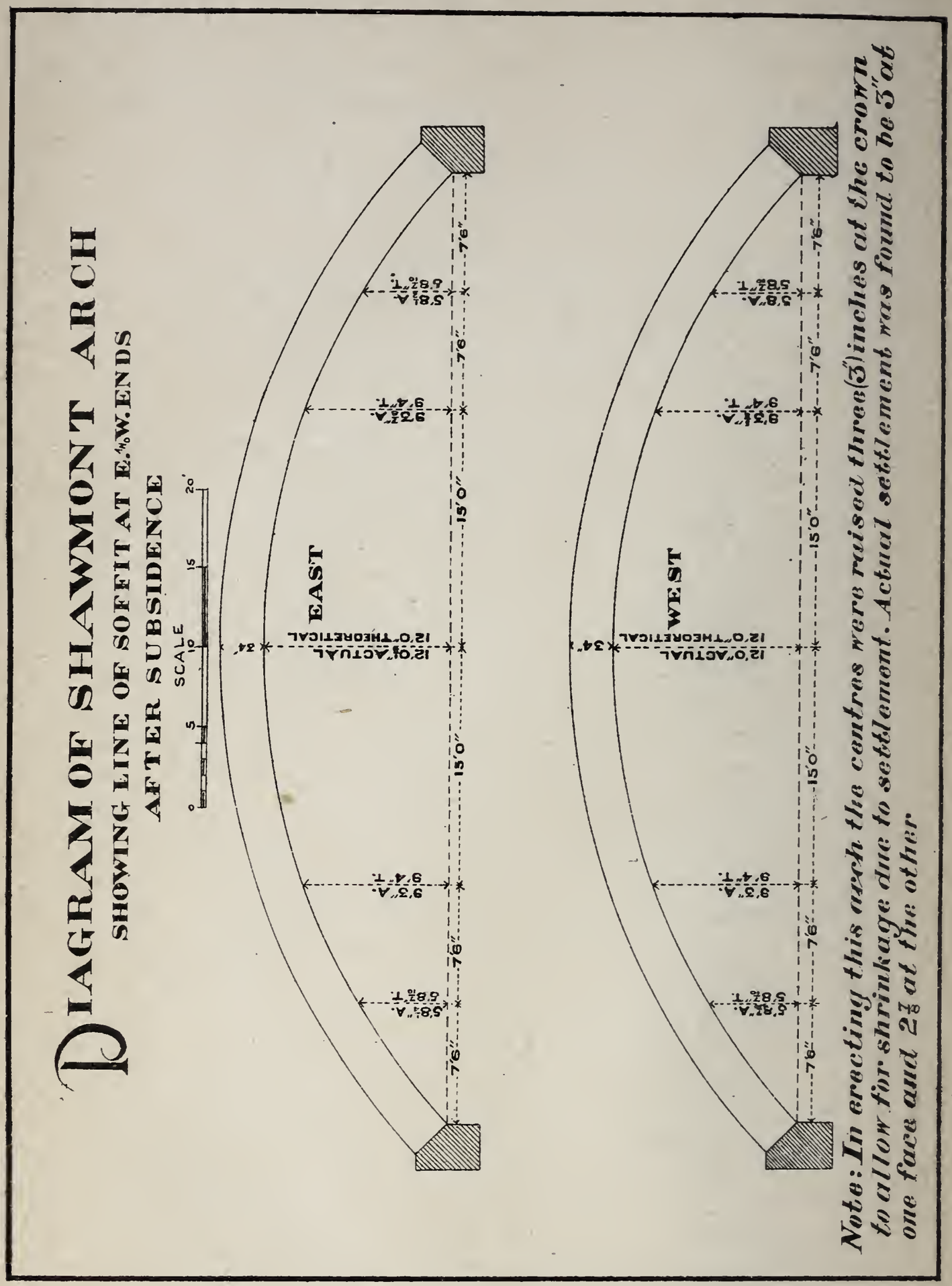


DIAGRAM OF SHAWMONT ARCH
SHOWING LINE OF SOFFIT AT E. & W. ENDS
AFTER SUBSIDENCE
SCALE
0
5
10
15
20'
EAST
WEST
12'0" ACTUAL
12'0" THEORETICAL
34'
15'0"
7'6"
9'3" A.
9'4" T.
5'8¼" A.
5'8½" T.
Note: In erecting this arch the centres were raised three (3") inches at the crown to allow for shrinkage due to settlement. Actual settlement was found to be 3" at one face and 2⅞ at the other

PLATE I.

Such supervision on the part of the engineer requires not only experience, but a certain deftness, which is its twin brother; he can not find the knowledge in the printed books, or at least, not all that he needs. But it seems to me that a work which is done is a book in itself, and if there are sermons in stones, there may be writings in bricks; so I will venture to read something out of two brick arches, 60 ft. and 50 ft. span, erected about two years ago.

They were in different localities, but are brought together here for comparison.

The 60-ft. arch was built first—it spanned a street, and was designed to carry a railway embankment, 9 ft. in depth over the crown of the arch. The principal dimensions were, clear span at skew-backs, 60 ft.; rise, 12 ft.; length of cylinder, 48 ft.; thickness of arch, 34 inches in eight rings, excepting under the parapet walls, where the uppermost ring was omitted. The abutments, skew-backs, wing-walls, parapet and backing were of sandstone, the arch only being of brick.

It being necessary to keep the street open for travel, the centres were framed with care: had five lines of vertical supports stepped on heavy sills, with double wedges under each post. After being adjusted with great nicety, tell-tales were placed on every post, and on all the rows transversely, so as to detect any settlement of the centres. [None occurred.] The arch was very carefully turned, in separate rings but bonded where courses coincided, which were caught up and keyed out on the back with slate. All the material used was of excellent quality. The work was performed at a very favorable season, and by skillful men under constant inspection and careful supervision—in due time it was completed, the backing well carried up and built into the abutment, and the earth embankment placed evenly in layers to within about 6 ft. of grade. At this time, which was about two weeks after the arch was keyed, the centres were slightly slacked, and no settlement was observable in the arch.

The centres had been placed three inches (3″) high at the middle to allow for contemplated shrinkage of joints, but, owing perhaps to the very thorough workmanship and tight keying, the arch remained stationary: there was already so much load

on it that it was thought safe to cary up the spandrel walls and parapet to the full height, and there were still no signs of settlement. The centres were then removed for the reason that they were to be re-framed and used for the 50-ft. arch. The coping was set on the parapet, and the embankment brought nearly up to grade.

To all appearance the structure was reasonably perfect. A few days afterwards a heavy rain storm, the first for a long interval, set in, thoroughly saturating the earth-filling, and soaking through into the still green masonry. The next day I received a telegram from my assistant, saying: "The Shawmont arch is falling. Come at once." I found the inner ring of brickwork along the whole length of the northern skew-back badly crushed; about one brick in every five had returned to its dust. This being in plain sight from the street, there was quite a local panic, and it looked very bad for the arch. But there was not a crack in the whole soffit, not a joint had opened, and the curve was perfectly true. There was no failure of brick on the southern skew-back, and I soon felt satisfied that the crushing was due to the joints of the inner ring being closer than those of the others. I at once put masons to work, cutting out the crushed bricks and driving in sound ones in their place, and partly unloaded the earth as a prudential measure, although, as it turned out, that was not necessary. The second course of brick was intact wherever disclosed by the workmen, and no further settlement took place. The skew-back was not injured, excepting in the extreme end, where it was slightly spawled. An accurate measurement (see Plate I) of the intrados showed that the arch had come down to within $\frac{1}{8}$ of an inch of its intended rise, and no part of the curve varied more than one inch from the true circle. But as the courses of the spandrel and parapet had been set level, of course they were now curved downward, and it was necessary to re-set a portion of them. The abutments had not yielded: the embankment was afterwards raised to its full height without any further subsidence.

Meanwhile the other arch was being built. It was in general like the first one, but had a rise of 12 ft. in 50, and was built on a skew of 17°.

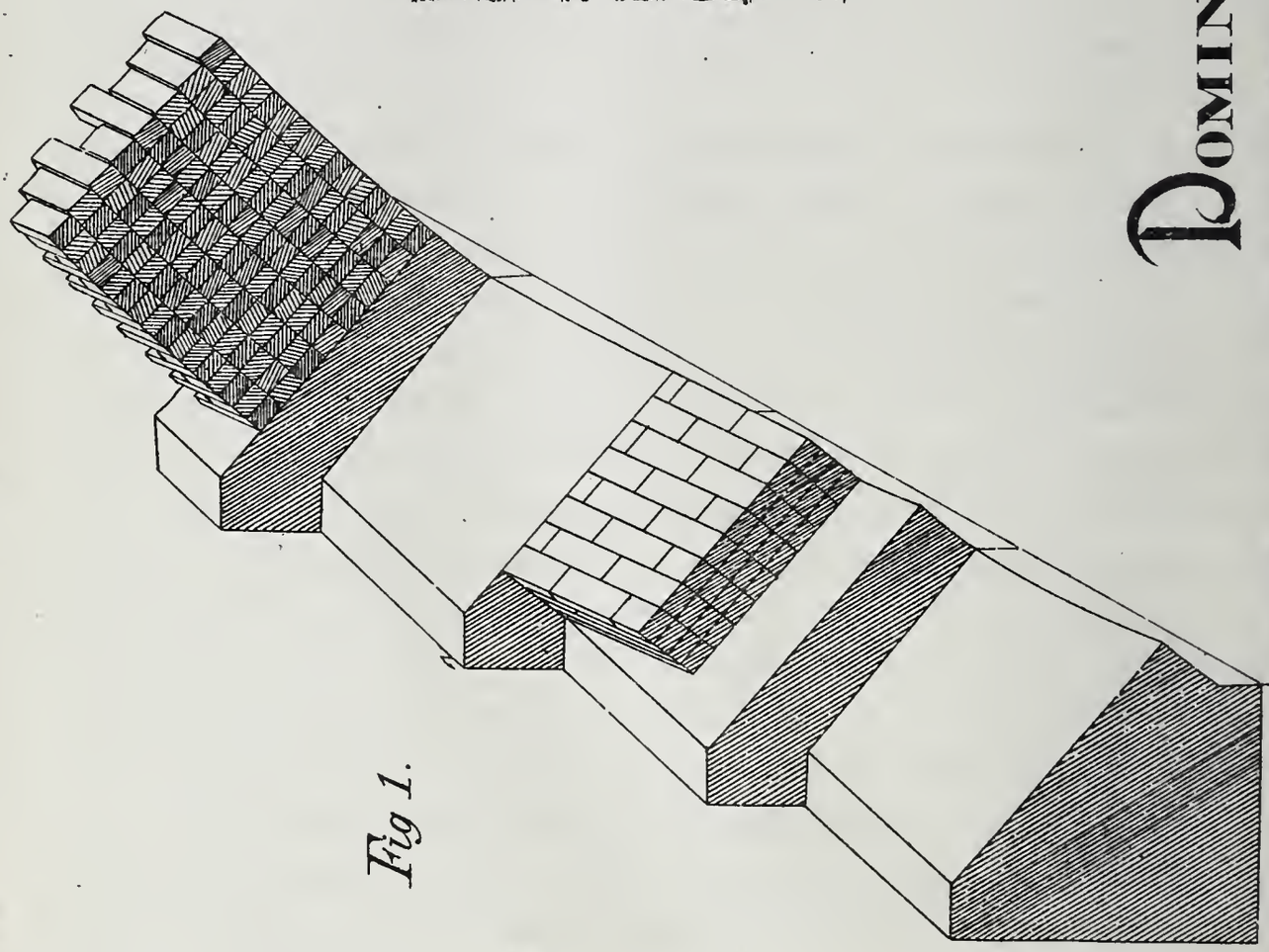
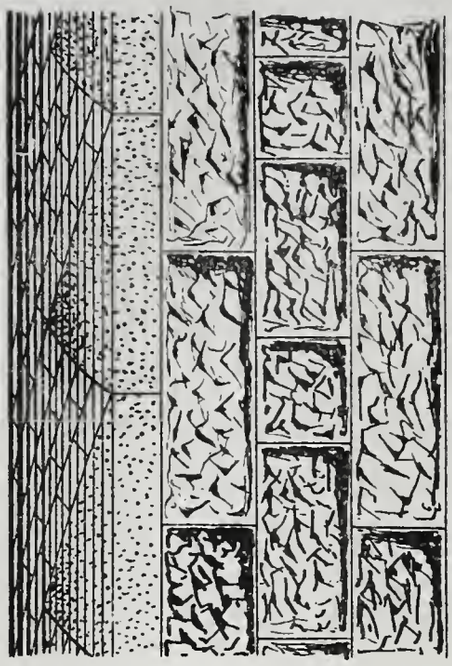


Fig 1.



ELEVATION

Fig. 2.

DOMINO ARCH

SKEWARCH SAW-TEETH SKEW-BACK

ISOMETRICAL PROJECTION

0 3" 6" 1' SCALE ½' 1' 2' 4'

PLATE II.

The bricks were laid in spiral joints with saw-teeth skew-backs. (See Plate II, Figs. 1 and 2.) As there seems to be a reluctance in many quarters to use spiral joints, due, I think, chiefly to the mistaken idea that they are more troublesome, I will so far digress as to describe the modus in this case. The intrados is a segment of a right cylinder, intercepted by two parallel planes making an angle of 17° with a line passing at right angles to the abutments, and the axis of the cylinder. The lines of the joints which extend in the same general direction as the abutment, are helices. (Plate III, Fig. 1.) We can conceive a helix, to be described on the surface of a cylinder by a point at the outer extremity of a radius normal to that surface, revolving about the axis of the cylinder at a uniform rate, and advancing along the axis at a rate also uniform; the ratio of the two rates will be the order of the helix, and the lateral projection of the angular motion at any point will be the sine of the inclination of the radius vector from its initial position. If then by developing the surface of the skew cylinder, and laying down a line normal to the developed margins, passing through the middle point of the surface, and then giving the horizontal projection of that line its true position on the plan, we can readily deduce an expression for the position of any point of the helix in rectangular terms of its proportionate motion parallel to the axis, and the sine of the corresponding angle of revolution. A straight horizontal line lying in a vertical plane cutting the cylinder at the points a and b, (Plate III, Fig. 2) can be expressed in terms of the parallel motion and the sine of the total angle. It therefore follows that the horizontal distance between the position of a point on the helix and the vertical plane passed through three points of the helix, measured at right angles to the axis of the cylinder, will be proportional to the sines of the angles of revolution. And if $\propto$ represent the angle of revolution made by the radius vector in passing from a to b, and R the radius of cylinder, then the distance from the vertical plane to the point midway is equal to $(\sin. \frac{\propto}{2} - \frac{\sin. \propto}{2})$ R. And the ordinate at the midway point $= \left(\sin. \frac{\propto}{2} - \frac{\sin. \propto}{2}\right.$ R $\times$ cos. of skew angle.

In laying out the work it is only necessary to fix on the centres the points *a* and *b*, and place a transit instrument in their vertical plane. The calculated distances for the middle spiral can then be readily set off. All the spirals are equi-distant and of the same order. The transit need not be used except for the middle one, but it is better to use it throughout, and for brickwork the delineated spirals should correspond to every tenth course, to get good lines. In this case they were chalked directly on the lagging of the centres and closely adhered to. The saw-teeth skew-backs are illustrated in Plate II. Because of difficulty in securing stone sufficiently large, they were made to intercept only four spiral courses. At one end they are of the normal shape, the other extends into the soffit the width of four courses. Care was taken to ease away the extreme projection, so as to avoid overstraining the stone, which is of course weakest there, and to throw the pressure on to the outlying bricks. All skew-back stones were cut to one pattern, excepting, of course, two corner-stones, whose faces are reversed.

A plaster model of the stone was made to scale, and the brick courses drawn in red lines, shown on it, and full size templates given to the contractor. Before beginning the work, however, it was necessary for both him and his foreman to see an actual example of this form of construction, which was found under the New York approach to the Brooklyn Bridge. After the experience with the sixty-foot arch, I was quite concerned lest a similar occurrence should take place in the skew-arch, which would have been fatal to the saw-teeth. The centres were set $2\frac{1}{2}$ inches high at the middle, and I hardly hoped to avoid some shrinkage at least. While revolving the subject in my mind, it occurred to me that the backing in the spandrel filling could be called into requisition to distribute a considerable amount of the thrust in the arch, and relieve the skew-backs materially. Ordinarily the back is made of rough stone, and there is not much opportunity to form a union with the arch member save by friction. I therefore determined to employ bar iron to form a bond, using bars $3'' \times \frac{3}{8}''$ and about 18 inches long, built into the brickwork and projecting into the backing, which was afterwards carefully built around them and the whole wedged firmly.

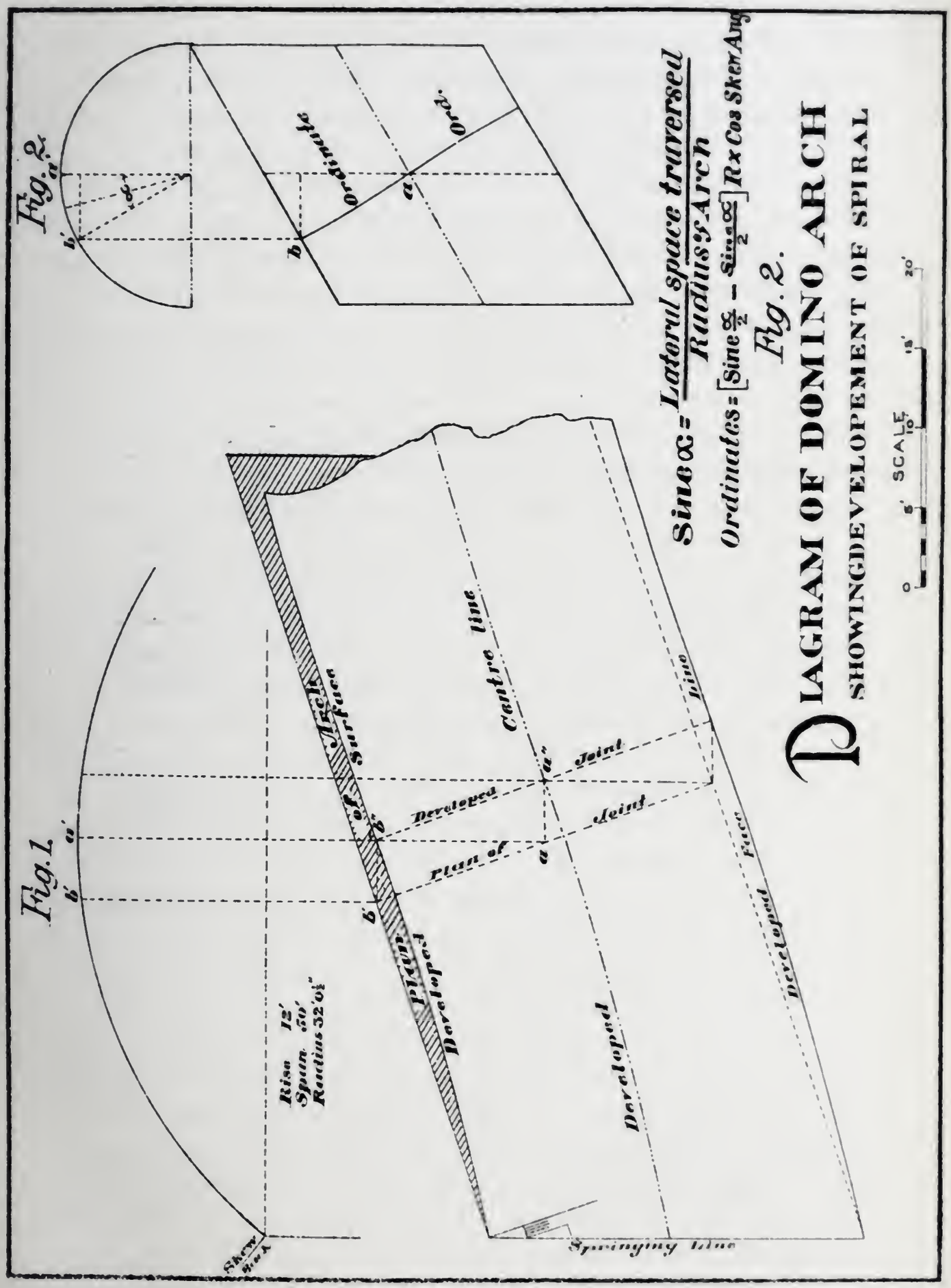


Fig. 1.
Fig. 2.
Rise 12'
Span 50'
Radius 32'0½"
Skew Back
Plan of Developed Arch Surface
Developed Plan of Joint
Developed Joint
Centre line
Springing line
Developed Face
Ordinate
Ord.
Sine α = Lateral space traversed / Radius of Arch
Ordinates = [Sine α/2 − Sine α/2] R × Cos Skew Ang
Fig. 2.
DIAGRAM OF DOMINO ARCH
SHOWING DEVELOPEMENT OF SPIRAL
SCALE
0 5' 10' 15' 20'

PLATE III.

These bars were used well up over the haunches of the arch. After the brick and backing were completed, they were allowed to remain a few days before the earth embankment was placed up to grade over as much of the width of the arch as possible. Then the centres were slacked at the middle but kept tight under the haunches and at the skew-backs. No settlement took place. After two weeks the wedges were struck under the haunches, when the arch subsided $\frac{3}{8}$ of an inch at the crown. The parapets were then built up and finished, but the centres were kept tight against the skew-backs for several months; when finally removed there was no further settling, and no crack or opening of any kind in the whole structure.

I have endeavored, in this presentation of the subject, to answer a very worn-out question without propounding it, or rather to let these facts answer it. I think that they establish certain truths which can be formulated as follows:

1st. That the centres should be left under an arch as long as possible. That they should not be struck until the whole contemplated dead load has been carried for several weeks, dependent on the season, and that they should be first slacked under the middle of the arch, and kept tight under the haunches, until it is absolutely necessary to remove them or until they rot.

2d. That the allowance for shrinkage, if proper care be used, need not be nearly so great as is usual and as was here adopted; in the first case it was unnecessarily large, because crushing began *before* the arch had reached its intended permanent position, while in the second case the total settlement was actually only about $\frac{1}{6}$ of the allowance. The limits and scope of this paper will not allow me to more than touch on the matter of shrinkage. Its degree is mainly a question of the setting quality of the cement used, but the element of the time consumed in building also enters. In these days of insane hurry, and especially in our own country, the engineer has little opportunity to make haste slowly.

When time and care have been expended, however, a marked diminution of shrinkage has been obtained. As an instance, I could quote the case of the massive tower of the Produce Exchange, in New York, which is upwards of 200 feet in height, and supports an immense load on its many intermediate floors.

For the first 100 feet above its foundations, three of its sides are of brickwork, while the fourth is of cast-iron, and consequently unyielding.

The entire shrinkage of the former has not been perceptible, as stated by the architect, Mr. Post, and the reason he gave was that he had caused it to be built very slowly.

To return to the immediate subject—it might be asked whether the great difference in the shrinkage of the two arches can be attributed entirely to the difference in treatment. I think not. The comparison is not quite equal, because the 60-foot arch carries more load per foot, and besides being flatter, the pressure per square foot on the brick ring is considerably greater. It is not possible to accurately determine what proportion of the gross load is transmitted directly by the brick ring; in the 60-foot arch a larger share is thus taken than in the 50-foot arch.

Theoretically the sum of the entire dead and moving load would produce a resultant pressure of nearly 15 tons per square foot on the ring at the skew-backs, in the first instance, and about 12 tons in the second, making factors of safety respectively 6 and 8, taking the results of Mr. McArthur's tests of cement brickwork for ultimate crushing strength, but the actual working stress is undoubtedly materially reduced by the supporting power of the backing near the abutments.

XVIII.

ENGINEERING; ITS ACHIEVEMENTS AND ITS REWARD.

By C. W. Buchholz, Active Member of the Club.

Read December 5th, 1885.

Professor Reuleux read, about a year ago, before the *Gewerbe-Verein* in Vienna, a very interesting paper, entitled: "*Kultur und Technik,*" of the beginning of which the following is almost a literal translation. He says:

"In taking a broad view over the present condition of culture in this world of ours, we cannot fail to see what an all important influence is exerted by technical skill based upon scientific prin-

ciples, and as practiced in our days. No one can ignore how it has helped us to accomplish incomparably more material progress than was possible to mankind a few hundred years ago—be it in the domain of rapid transportation of passengers, or of heavy cargoes by land or sea; be it in the tunneling of great mountains, in the boring of deep mines, or in the ascending high in the air; be it in sending with lightning rapidity our thoughts around the earth, or in transmitting our voice for hundreds of miles across the country; be it on the one hand to control the mightiest forces and to compel them to do us mechanical service, or be it to utilize on the other hand the most subtle processes of nature, elements of the material world so delicate and fine that they almost escape ordinary observation.

"Everywhere in our modern life, here, around us, upon us, with us, and near us, wherever we go, technical science has become our busy servant and companion, in ever restless activity, the influence of which we never really appreciate until we have to do without its assistance for ever so short a period. All this is well known, and has become almost commonplace, yet it appears to me that it is not so thoroughly established as it should be among educated people, and not even in the narrower circles of men of technical training.

"The world does not as yet look upon technical science by any means as the great lever and factor of culture, which it really is."

The Professor then goes on to hint at the probable cause of why this is so, but he does not advance any definite reasons, and he refuses to deliver a panegyric on "Technic," or "Engineering," as I will call it hereafter, for the latter nowadays embraces nearly all the first implies; and he declines to demolish by his facts and logic those who refuse to give to the Arts and Sciences the long-hoped-for acknowledgment. He, however, very ably proves and shows what the true position of Engineering is in the universal activity towards the solution of the great problem of culture, and he very clearly points to the methods it has ever pursued since the earliest times.

Now, I would like more particularly to draw the attention of the Club to the very question the Professor leaves unanswered, but which seems to me to be of the greatest importance to every man of mechanical training, to every engineer who has selected

his profession, not in order to maintain a precarious and humble existence, but rather to rise above his fellow-men, and become a distinguished member of society; a leader of progress, as well as the pioneer, corresponding to his higher education and to his responsible and arduous duties. Why is it that in every highly civilized community the men graduating from the classical departments of universities generally at once take a higher social position than those coming from polytechnic schools? Why is not the degree of Doctor conferred upon the engineer as well as upon the lawyer, the physician, and the preacher? Why is it that all other professions have far outstripped him in their social and political influence? Surely the engineer has done much more for the general development of the resources of our mother earth and for the progress of mankind, and has accomplished much more towards making "life worth living" than any other profession, be it ever so classical or learned in the laws, in medicine, or theology.

Leaving out of consideration the temples, and palaces, and public buildings erected during the very earliest periods of recorded history in Eastern and Central Asia, whose people, although rich in poetry and culture, have remained stationary in technical knowledge for many centuries; ignoring pre-historic peoples and their monuments, and beginning our review with the nations bordering on the Mediterranean, we find there the birth-place of the engineer, the architect, the astronomer, and the mathematician. Nearly all the records of primitive times chronicle little else but deeds of heroism during everlasting wars between different tribes and nations, and it is to be presumed that the first employment for the engineer must have been with their armies, making roads and building crude fortifications. Mechanics and craftsmen of all kinds were very scarce, and it is no wonder, as Homer tells us, that the great Ulysses himself, the hero and chief of a nation, had to construct with his own hands the ships he sailed in, and had to design and execute in person the decorations of his palace. But as the savage spirit of perpetual war somewhat subsided, and as commerce increased, and as navigation began to be better understood, it soon became necessary to improve the natural shelter of harbors by artificial means;

and to the Phœnicians, probably, belongs the credit of employing the first civil engineer to construct the celebrated and ancient harbors of Sidon and Tyre. This enterprising people, as long ago as 1280 years before our era, passed the Straits of Gibraltar in their ships, and founded the port of Cadiz, where they erected docks and large warehouses to accommodate the goods of the then known world.

Egypt, another country of the greatest antiquity, deserves undoubtedly the credit of being the cradle of all science, and of nursing it with the greatest care. Greece drew all her knowledge from there, and it must be admitted that a great amount of modern engineering skill had its origin on the banks of the Nile; 2300 years B.C. a king of Egypt changed the course of the Nile from the foot of the sandy mountain on one side through the centre of its valley, by constructing new and deep channels and several canals. By this simple method he reclaimed thousands of acres of marshes, raised the surrounding low lands by filling with the material excavated, until it was above the annual inundations of the river, and thereby enabled his successor to build large cities with safety upon sites thus raised above the floods. Each successive monarch improved and continued the construction of canals and storage lakes, until the whole valley of the Nile became the most fertile and prosperous country on the face of the earth, and 4000 years of misrule and fanaticism have been unable to this day to destroy the results achieved by the system of drainage and irrigation as founded by King Mines and his engineers. The construction of the pyramids, obelisks, sepulchres and magnificent temples, especially those of Isis and Serapis, together with other innumerable monuments of antiquity, was perhaps the joint effort of the engineer and architect, although it is most likely in those early times the two professions were not divided as they are to-day, and they are still depending more or less upon each other for success.

The inscriptions upon nearly all these proud remains of ancient skill show conclusively that the chisel, the mallet, and nearly all the tools as used in our present time for the quarrying and dressing of stone, were known to the old Egyptians, and it is marvelous to contemplate how thoroughly the principles of the lever

must have been understood by them, in order to move for many miles from the distant quarries, and raise to great heights, the enormous masses of stone used in their construction.

The great development and the high cultivation of the sciences and arts rapidly increased a taste for luxury and ease, and naturally destroyed the warlike spirit of the people of Egypt. They were in turn conquered and oppressed by the Greeks and the Romans, but the material progress founded by their engineers upon the laws of nature, then just dawning upon the brightest minds, could not be suppressed; the conquerors became the pupils of their slaves, and both the Greeks and the Romans carried their newly acquired knowledge home with them, enlarged upon it, and used it with skill and energy, so that the then known world was rapidly changed. Wherever the conquering arms of the Romans were carried, through Gaul into Germany, and over to Britain, through Greece into Asia Minor, and India, to the very gates of Cathay, the engineer followed and often led the way. Without his assistance and skill it would have been impossible for the Romans, in spite of their disciplined courage and their great administrative ability, to keep together for so long a period the vast incongruous empire they founded. The magnificent highways constructed by their engineers, the artificially improved and well defended harbors selected by them, the temporary but very effective defences thrown around their camps, the strong walls and deep moats they built around their outlying fortifications in distant provinces, and the enormous engines of war for defence and offence, invented and brought into practical use by their mechanics, enabled the consuls and emperors of Rome to move and concentrate their legions with great rapidity, and to hold far away settlements of importance for many months against the fierce attacks of barbarians, until assistance could be brought forward from the centre of life and energy at Rome. Besides the constant activity of the military engineer, for Rome was rarely without a great war on its hands, the civil engineer was never idle during the many centuries of Rome's glory. The whole empire, as it existed during the reign of the Antonii, bore witness of the scientific knowledge, and genius, and energy of its engineers. Not only in Italy, but also in every

conquered province from the Atlantic Ocean to the borders of India, from the Baltic Sea to the Sahara Desert, the engineer of that period has left great monuments to attest his skill and fertility of mind. The many miles of costly aqueducts scattered all over the Empire, the innumerable public and private baths located in every city founded by the Romans, the immense amphitheatres, the magnificent temples and palaces, the handsome and numerous stone bridges, some of them unrivalled in their magnitude even in modern times, the great network of canals for the uses of irrigation or navigation, often cut through mountains without the use or knowledge of any explosives—all of these stupendous works constitute the imperishable evidence of the important part the engineer has always played in advancing material prosperity and civilization.

Of all the great engineers that must have existed during these ancient times, Archimedes, of Syracuse, was probably the greatest mechanic; he is at least one of the few men of that type of whom we know anything definite. Everyone is familiar with the wonderful defense of his native city, as conducted by himself by means of his mechanical engines of war, until he was slain at the age of 78 by a common soldier, during a successful assault of the Romans. He is, above all others, the one man who laid the foundation of scientific research, the prosecution and improvements of which are the boast of the present day; but especially celebrated is his treatise on the principles of hydrostatics, which he studied during his travels in Egypt, and upon which are erected all the theories of hydro-dynamics and hydraulic architecture, as practiced by the engineers of Italy and France after the Renaissance.

During that long period of the Dark Ages, from the downfall of the Roman Empire to the beginning of the 17th century, the civil engineer can hardly be said to have existed; brutal ignorance and mental darkness took again possession of the earth, nations were again annihilating and exhausting each other by constant wars, and every tyrant and religious fanatic seemed to be bent upon destroying what his ancestors had created for the benefit of mankind. The Sciences and Arts were only partly preserved, and only practiced in secret, either by a few monks

superior to their kindred, or by the Free Masons, the Brothers of the Bridge, and a few other secret societies.

To Rome belongs the glory of having accomplished, by her enterprise and knowledge, more than any other nation of antiquity for the development of the resources of our globe, and to Italy belongs the credit of reviving culture, the Sciences and the Arts, after the religious bigotry that kept men's minds in bonds had been challenged and attacked by the liberty loving people of northern Europe. It may be said that the civil engineer reappeared about the middle of the 17th century, when it became necessary to drain the marshes and submerged lands of Italy. Many eminent writers on philosophy and mathematics arose about that time, and the sound theories they established, gave a new and better light for practical work to the engineer and mechanic. Galileo and Descartes were the great teachers of that period, and made rapid advances in the true understanding of the forces of nature. Since the time of Archimedes, the theory of equilibrium had been understood and practiced, but Galileo taught, and explained, and believed in his theories of motion, and Descartes made complicated problems and tedious calculations soluble and comparatively easy by the introduction of algebra. Ever afterwards and up to the present time, progress, especially in mechanical engineering, has been constant, and within the last hundred years, enormous.

When in the beginning of the last century, England furnished a Newton, and Germany a Leibnitz, to teach the true principles of dynamics and of pure mechanics, the minds of practical engineers were prepared and ready to utilize their knowledge, and apply it successfully to the steam engine, invented by James Watt.

It can hardly be said that the civil engineer was known in England and France until the beginning of the last centnry. The celebrated school of *Ponts et Chausées* was established in France about the year 1720, and from it have since graduated some of the greatest mathematicians of Europe, and many able and practical engineers. England, although she had produced a few engineers of eminence in the construction of canals, and harbors, and lighthouses, never gave evidence of all the technical skill that lay

dormant among her people of sailors, merchants, and country squires, until the steam engine was introduced in some of her factories. But then her progress was rapid, and her increase of manufactories, mining industries and commerce, grew to such enormous dimensions within a hundred years, that she not only outstripped in influence and power all the other nations of Europe, but made the magnitude of Rome in her proudest days seem insignificant compared to the wealth, and learning, and strength of the British Empire.

The power of steam, and its application to the manufacture of iron, and to the production of every article of luxury and necessity that enters into our daily wants, has produced a far reaching revolution, not only in trade and commerce, and in the intercourse among the nations, but it has radically changed the very thoughts of men, until there is a larger gulf between our modern life and that of ancient Greece and Rome, than there was between those cultured nations and the wild and naked hordes of the Scythian desert.

When finally the immortal Fulton applied steam for the propulsion of vessels through the water; when Stevenson ran his first locomotive engine from Liverpool to Manchester; and when Morse applied electricity to the telegraph, the revolution in our mode of life appeared almost completed, and man's power over the forces of nature and its elements, so constantly working against him, seemed well nigh absolute. The human mind would be overawed by the results of its own achievements were it not so constituted by the rapid increase of physical science and the accumulating inventions and discoveries of mechanical contrivances and natural laws, as to look upon every new improvement as a matter of course, until the telephone, and the electric light, and the electric engine have become no greater wonder to our children "than the cooking of a dumpling, although the question as to how the apples got into it, has been a mystery to some minds."

It would require volumes to recite with anything like justice, the enormous works executed by public and private enterprise within the memory of living men; it would take column after column to record the names of eminent mathematicians and en-

gineers who enlarged the scope of scientific knowledge and carried it into practical execution, and it is impossible in an address so limited as this is meant to be, to dwell upon these interesting matters.

Leaving, therefore, out of consideration the great wealth expended within less than a century by the nations bordering on the Northern Atlantic, in sanitary, and mining and military engineering; on the improvements of harbors and the construction of steamships and docks; on the development of cheaper methods in the manufacture of iron and steel; on the erection of immense establishments for supplying water, and light, and clothing, and hundreds of other daily necessities, that have put it within the reach of the poorest laborer to live in more bodily comfort than the well-to-do citizen of antiquity—putting aside these important enterprises and looking only upon one great achievement of modern engineering, the construction of railroads all over the known world, then it becomes at once apparent what immense progress we have made in technical knowledge, and what infinite benefits mankind has derived from it.

When the future historian, perhaps Macaulay's New Zealander, shall chronicle the history of our times, this generation will not become celebrated by the beauty and grandeur of its architectural remains, nor by the romance and sublimity of its epic poems; but on account of its knowledge of natural law, of its technical ability, of its practical skill in engineering, and on account of the comfort, the health, the freedom and the enjoyment that these acquirements have brought within the reach of the humblest of mankind.

The treasures spent by the ancients during long centuries of their supremacy, upon temples and other monuments of architecture, fade into utter insignificance when compared with the fabulous sums of money expended on the construction of railroads alone within the last fifty years.

Poor's Manual of Railroads for 1884, gives in his review of the year 1883, for the United States alone, a mileage of 110,414 miles of railroad completed and in operation. They were constructed at a total cost in round figures of $7,500,000,000, and the gross earnings of that one year amounted to $833,000,000 of money, a

sum larger than the revenues of the British Empire and the United States put together. All this vast amount of wealth has been invested, not to satisfy the vanity of some great General or Emperor, not to glorify some pagan deity, or to cater to the taste of a turbulent populace, but in order to consolidate a great and free nation, to make possible the daily intercourse of a people living thousands of miles apart, and to exchange freely and rapidly and without interruption, the products of their labor.

Surely the engineer is entitled to the lion's share of the credit due in bringing about this unparalleled prosperity of the country. From his brains originated all the designs for the large and substantial bridges that carry our highways and railroads over the largest rivers, and thereby overcome the barriers nature had put there. The engineer conceived and located, and he supervised and directed the host of laborers, craftsmen and mechanics that constructed and equipped the many thousand miles of railroads, that made the rapid development of this country possible. Daily millions of people trust their lives and fortunes to the care and skill of the engineer, to his ability and to his integrity—on the decks of steamboats, crossing oceans and lakes, and ascending and descending rivers; on railroad trains, crossing continents with uninterrupted rapidity; in our palace hotels, and in public halls, yes, in the very privacy of our houses, the whole community, from the lowest to the highest, is constantly at the mercy of the engineer, and any neglect on his part would at once be the cause of a great calamity, or of far reaching annoyance and inconvenience. Yet with all this responsibility resting upon his shoulders, and often overburdened with care and worry brought about by the dangers of wind, and fire, and water, the elements that constantly threaten to destroy in a few moments what he had so carefully constructed during weeks and months of anxious labor, and after years of honest toil, the engineer finds his reward generally in obscurity, and without financial success, with his health destroyed and nothing to console him, save the proud consciousness of having done his work well and to his own satisfaction.

The name of many an able engineer is entirely unknown, until by some misfortune and accident, or perhaps by some oversight of his own, one of his structures fails and causes the loss of life

and property; then he becomes at once a public character and gets to be notorious, but not famous, as he had fondly hoped to be. Every school-boy has on his finger-ends the names of kings and Cæsars, and orators of Rome, but who knows the name of the engineer that built the "Appian Way," or the "Aqua Claudia?" Everybody who can read a newspaper is familiar with the names of the emperors, generals and statesmen, and public agitators of England, and Germany, and France, yet there are but few men, even in the profession, that can call by name, or know anything of the lives of the men who built the London and Liverpool docks, the first Thames tunnel, or the steamship Great Eastern; of the history of the engineers who built the Mt. Cenis or the St. Gothard tunnels? I am afraid able and scientific engineers in this country are not much better known, and are much more rapidly forgotten than many a disreputable politician. The construction of our Pacific Railroads have ceased to be wonders; the East River Bridge, the most stupendous piece of work ever conceived and completed, is used by the public with the same indifference as a ferry boat, and the great explosion of the rocks at Hell Gate, a feat of engineering skill so colossal and frightful in its responsibility, was forgotten a few days after it was fired.

One would naturally suppose that the construction and management of railroads would bring the engineer prominently to the front, but such is not the case. "Financiers" and "business men," without any knowledge whatever for the position, except their judgment, good or bad, are put above him, and his technical training is often a drawback to his advancement.

It is true there are a few conspicuous examples of railroads in this country that are entirely controlled by engineers, and I need hardly dwell upon the good result obtained, and upon how much such management is to their credit. It is a well-known fact, not only to railroad men, but to all the traveling public, that the railroads so controlled are infinitely superior, especially in their physical condition and equipment, to those managed by men without technical training, be they ever so able and energetic otherwise. I would like to go into detail upon this subject, but the natural modesty so common in our profession bids me halt.

It is, however, a constant wonder why the great men of finance

and those who by their investment control the management of railroads, and who have suffered so much during periodic railroad depression, will learn nothing from experience, and will not accept the evidence of successful management by men technically trained for that purpose.

I think that nearly every engineer, at least all those who have devoted their time, and energy, and health to the business, will agree with me about the subordinate position held by them, when compared with the other professions generally called classical and learned.

If this is admitted, it becomes the duty of everybody to look for the cause and to go to work and find a remedy. Perhaps a great many engineers neglect business habits and confine themselves too much to technical questions; others again pay no attention to culture and general literature; and others still become unpracticable because they devote all their time to pure science and mechanics, which should be left to the Professor. But I believe the majority are kept so constantly down to the ordinary drudgery in order to get their bread, frequently without butter, that they lose all interest in study and fall behind their more fortunate neighbors. I have no doubt some blame for all this is due to our Polytechnic schools; their training is too narrow and not far reaching enough to enable its graduates to cope successfully with the ever increasing demand made upon the profession both in Culture and Technic.

There is one grand remedy for this evil that I would not only suggest but urge upon all, namely: unity of action, harmony among ourselves, and mutual support. The lawyers give us a shining example in that direction. I have come in contact during my career with many eminent men in that profession, and I have always noticed that although during disputes in open court or before a master they frequently are full of wrath against each other, and spare neither satire nor innuendo to get the best of their opponent, yet outside of the arena, in private or in public, I have yet to hear the first unkind word, derogatory to his ability, spoken by one attorney against another.

XIX.

THE GREATHEAD SYSTEM OF FIRE PROTECTION, AND THE PUBLIC SUPPLY OF HYDRAULIC POWER.

By Howard Constable, Active Member of the Club.

Read January 16th, 1886.

Gentlemen and Fellow-Members:

I have had occasion recently to examine in person and report upon these two allied systems, as they now exist abroad, a description of some of the plant and methods of operating may interest you, and perhaps add a few points to what you have already heard, concerning these very successful and interesting enterprises and examples of modern engineering skill. They have not been as conspicuously set forth and heralded as many other enterprises, nor have the principles of the systems received the general attention they deserve, and the still fuller development they are capable of. However, they are long past the theoretical and experimental stages that all important systems must pass through. They are firmly established and steadily growing in favor with the users of power and the promotors of legitimate enterprises. I think the use of hydraulic power has not advanced as rapidly in this country, simply because very few of our enterprising men have known or appreciated fully the long experience abroad, and certain kindred experience in this country which latter, while also quite extensive, has been curiously inconspicuous to the generality of people. I will refer to this and illustrate it further on.

The Greathead system for fire protection is based upon the well-recognized principle and growing practice of fitting out a city with a large number of well located fire hydrants, which need but to be opened in order to instantly furnish a good fire stream, and thus extinguish a neighboring fire before it has gained uncontrollable headway. This is known as a "Hydranted City," and the principle, as expressed by an underwriter, is, "that any fire could have been put out at some time with a cup of water." The loss by fire from 1880 to 1882, in Glasgow, Manchester and Dub-

lin, has been put at 925 against 2,725 in London, Paris and New York (which are unhydranted cities), or about thirty-four per cent. in favor of the hydranted cities. It has been stated by Mr. Bateman, that the proportion of the property at risk, damaged by fire or water, in Manchester, under the system of high pressure hydrants, up to and including 1878, has been reduced to one-seventh of what it was before the introduction of the hydrant system. Certainly a most wonderful result, and indicates a system most desirable as an auxiliary to the fire department, especially in crowded cities with narrow streets, where the access for engines is so difficult that a small fire becomes a great conflagration before they can get the engines into position and throw a single stream upon it. The fire department, with its present methods, is essential for great cities; but there are some conditions it cannot overcome, and it welcomes this new assistant, the "high pressure fire plug." But in order to secure this valuable friend, we must have a pressure of water of 60 pounds per square inch and more at the hydrant, but we cannot employ this amount of pressure on the ordinary mains, for the general plumbing of the city could not stand it, nor in most cases would the mains themselves, and again, the conditions for securing this pressure by means of gravity supply is very rare, and by pumps very expensive. Thus only a few cities see their way to putting the principle into practice, but now the Greathead Injector Hydrant makes it much more feasible. It simply takes the water from the regular mains of the city, at the ordinary pressure, adding to it the required additional pressure for fire services, thus giving instantly a fire stream wherever needed. This is accomplished by a small hydraulic pipe, which feeds the hydrant with a small quantity of water at high pressure, which passes through the nozzle in the hydrant, draws a large volume of water from the city mains, combines with it and gives to it the requisite pressure or velocity, so that it passes out from the hydrant ample in volume and pressure for a fine fire stream. Thus only the necessary power is sought to be added to the water taken from the already extensive system of city mains, with their great volume of water, which stands always ready to be utilized. And it seems quite unnecessary to undertake to put in a complete new system of fire-

mains, and to secure an extra source of water supply. Especially when it is remembered that the total amount of water used for fire purposes is very small compared with that supplied for other purposes.

The average daily consumption of London is about 150 million gallons per day, and for fire less than 50 million gallons per year is required. In New York, the daily consumption is about 110 millions, and, although it is a city which requires much water for fire purposes, yet less than 150,000 gallons per day are found sufficient upon an average. Therefore the amount of water used for fires is many hundred times less than the volume of water supplied for ordinary uses, and the principle of only drawing from the pipe system, a huge reservoir, as it were, and simply adding the necessary power to convert it into a fire stream, is well based.

Where an entirely separate system of mains and water supply for fire purposes only is proposed, it is found that the large volumes of water needed all at certain times require very large mains, and reservoirs and pumps, necessitating, of course, great expense and also great inconvenience to the city in laying the large mains. This system of separate supply and pipes was agitated for many years in London, but finally abandoned. The distribution of hydraulic power, by means of small pipes, seems to be growing very steadily, and, together with the injector fire hydrant, promises to become very popular; especially since London and Hull have public supplies of hydraulic power which have been so successful, and Liverpool has decided to adopt the same system. The photograph which you see shows very clearly the arrangement of the Greathead Injector Hydrant in any street. The hydrant is connected to both the ordinary water main and the hydraulic pipe, a length of hose with a nozzle is kept attached to the hydrant, and all are enclosed in a box flush with the pavement. It is but necessary to lift the lid of the box, draw out the hose, turn on the water, and you have a fire stream to turn upon any fire within reach. The interior is very simple, with no moving parts, the injector nozzles being very substantial and simple in construction. Altogether it seems to be a very ingenious and practical device for the purpose, and its use has re-

cently also been extended to the automatic elevation of water in buildings.

Let us now look more particularly into the distribution of hydraulic power, and, for illustration, take up the plant of the London Hydraulic Power Company. Engineers are all familiar with some form of hydraulic machinery and the general principles of hydrostatics upon which it is constructed and operated, but in this country it seems not to have received the full attention it deserves. Its simplicity and practical advantages may be some time commented upon, and perhaps some surprise expressed that the system was not in more general use, but active developing of it has not been very great, and it is not without some surprise we see or hear of the enterprise our English cousins have shown in this field. As yet the public mind here looks with some doubt and sometimes fear upon the use of high pressures, such as are used for hydraulic work, not being aware how long and safely, how extensively and satisfactorily, this system has been in use, and that there are quite a number of examples scattered about this country. To many the use of water at high pressures seems dangerous and impracticable, but we are using them more than is imagined, in fields that are not generally known to the public.

First, the oil-pipe lines, where hundreds of miles of pipe are used for conveying the oil over the mountains and under the rivers to the seaboard, necessitating pressures as high as 1,500 pounds to the square inch. These lines, as some of you know, have been in daily use for several years, with safety to all concerned and great economy to those owning them. In the pressing of cotton and in the extracting of oil, as well as in the riveting of iron work, we employ hydraulic pressures sometimes as high as 5,000 pounds per square inch. Yet only about 700 to 800 per square inch is required in the public supply of hydraulic power, and it must be remembered that in case of any accident and bursting, the pipes but crack open, thus immediately relieving the pressure, and since water is incompressible it also does not expand, so there is not that same flying about of pieces as with steam at high pressures. And again, it is to be remembered that the very impression caused by high figures or large amounts, produces more than a corresponding degree of care and attention, so that the

very best results are secured in designing, in quality of material, and in operating.

Take the case of the limited express or fastest train on a railroad; it developes so much attention and interest, that it is said the chances of accident to it are less than with any other.

The use of hydraulic power in industrial fields was advocated as early as 1802, by Mr. Bramah, who wrote to Mr. Mallet that he was able to raise and lower goods and operate presses in a most surprising manner, and that it was a great mystery to people who saw it, but that he was so sure of the principle and the completeness of his device, that he would undertake to erect an engine in any part of Dublin, and convey power to all the cranes on quays and elsewhere; that he believed he would have all the cranage of the London Wet Docks to undertake, which would be, he says, the "grandest job ever done before." To-day, all the great shipping points of England are fully equipped with hydraulic cranes, hoists, and derricks. About forty years ago, I believe, Sir Wm. Armstrong commenced manufacturing and introducing machinery and pipes for this kind of work, and since then such other works, as the Hydraulic Engineering Works of Chester, have made a specialty of it, so that throughout England, and in other countries, there are many individual concerns operating complete hydraulic plants for raising and lowering all their goods, switching their cars and operating machines and tools. But the London Hydraulic Power Co. has for its object the general distribution of power, and is the out-growth of a successful enterprise in this same direction at Hull, which, in its turn, was a bold step forward in expanding the system as so far illustrated by the various individual plants. Liverpool is also to have a similar public supply. The Hull Company was started some eight years ago, and at first its growth was slow, owing to hard times, and the usual reluctance to make any change and adopt new methods; but it grew steadily, without accidents, until four years ago it emerged from that condition of want of balance on the right side between receipts and expenditures, which is so often fatal to new undertakings, no matter how great their intrinsic merit. During the last four years the Hull Co. has enjoyed uninterrupted prosperity, and the originators were encour-

aged to attempt the same system in London. So, in 1882, a Company was floated, and obtained the right to lay pipes and erect machinery within certain limits, and recently those limits have been extended, so that now there are more than twelve miles of distributing mains. The financial success was almost perfectly assured from the beginning, and is thoroughly so now. During the first half of 1884, the amount of water delivered increased over 40 per cent. The central station is located on Falcon Wharf, on the southside of the Thames, close to Blackfriars Bridge, and at the western extremity of the first district granted to the company. The location was chosen considerably on account of the enormous value of property in the old city and along the northside of the river; but now that a western district has been given to the company, the location is not peculiarly out of the way. The power is extensively employed at docks, railway stations, warehouses, manufactories, etc., etc., for operating elevators, cranes, derricks, capstans, presses, riveters, motors, hammers, and the like.

The cost of lifting one ton fifty feet has been done as low as one farthing.

There are four mains carried out from the central station: two to serve the old city and West End, and two quite independent for the southern district. Mains are on both sides of the river between London and Blackfriars Bridges, and are united by two mains across Southwark Bridge, and they have been under pressure since November, 1883. Extensions have now been made westward through Westminster district as far as Victoria Station. Each pair of mains are laid in a circuit, and in all extensions care is taken to avoid all dead ends, so that a supply can come from either direction. The mains all communicate with the two accumulators at the central station, and there are stop-valves about every 400 yards, so that any particular section can be isolated without interfering with the operation of the rest of the system. The mains are of cast iron, six inches internal diameter, and with enlarged section at the ends, which are flanged with holes for two bolts. The joints are spigot and socket, turned with fillet, and are made tight with a ring of gutta-percha.

There have been remarkably few leaks or breaks; this is espe-

cially remarkable when it is remembered how the pipes must be threaded through the intricate system of pipes, conduits and tunnels, which already exist in underground London. In this connection it can be noted that the well-proved feasibility of putting down this small short pipe rapidly without danger from accident or leakage, and a minimum of inconvenience to the traveling public, is claimed as a very strong point in favor of extending the system for general fire protection.

The valves on the mains are of the balanced type of lift valve, with waterway the full area of pipe. The balancing is accomplished by a small $1\frac{1}{2}$ inch controlling valve; the only work to be done by the turnkey being raising the small valve and the dead weight of the large one. By this means, a six inch valve, which is pressed to its seat with a force of about nine tons, can be easily manipulated with one hand.

The water supplied through the mains is taken from the Thames, and you can readily understand is not entirely in a condition even suitable for power purposes, being charged with mud and other matter. A filter, known as the Thames filter, has been adopted. They are arranged in pairs, each filter having a capacity of about 10,000 gallons per day.

Each filter has a perforated diaphragm, connected with a hydraulic cylinder, which maintains a pressure upon a mass of sponge below the diaphragm.

The water from the river is pumped by centrifugal pumps, run by the ordinary three-cylinder engine, into a large tank over the engine house. The water is drawn from any one of the three compartments of this tank, passes through the compressed sponge in the filters into another tank, from which it passes on to the pumps, thence to the accumulators, and then out into the mains.

No attempt is made to remove any chemical impurities, as the water is only used for mechanical purposes. After passing through the filter, it goes through a small bed of vegetable charcoal, which removes any fine particles which may have passed the sponge, and also brightens the water a little. The filters have to be cleaned two or three times every twenty-four hours, which is done by reversing the flow of water, and putting the sponge through an alternate squeezing and relaxing process by means of the

hydraulic cylinder, to which the perforated movable diaphragm is attached. The pumping engines are designed by Mr. E. B. Ellington, and are of the three-cylinder, vertical, fly-wheel type. The middle cylinder is high pressure, and the outside cylinders low pressure; the respective diameters being nineteen and twenty-five inches, with twenty-four inches stroke—80 lbs. per sq. inch being the working pressure.

The fly-wheel shaft is, of course, three throw, and driven by split connecting rods, as the pump plungers are in line, and directly connected to the piston rods.

The pump is single acting, five inches diameter, and with five inch valves.

The valve gear is known, I believe, as the "Corry" type. The engines are controlled by the accumulator, and start and stop according to the demand for more or less water. The engines are fitted out with surface condensers, and with air pumps. The pumps deliver into two accumulators, twenty inches diameter, with twenty-three feet stroke and weighted to give 700 lbs.

The engines have stood the work well that they have been called upon to perform, and altogether are an interesting piece of machinery, but are considerably at variance in many respects with some of our ideas concerning the principles of design best adapted for hydraulic pumping.

The accumulators are of the ordinary form, and are so moderate in size that their function is more that of a safety valve or equalizer of pressure than a reservoir, since their storage capacity is very limited.

The boilers are of the Lancaster type, fitted with mechanical hoppers, feeders and stokers, and elevator, which are all operated by a small hydraulic motor. It is very interesting to watch such an arrangement: to see the coal hoisted out of the barge by a hydraulic crane, elevated by a chain of buckets and then conveyed along to the hoppers, and delivered by them as required to the mechanical stokers. It certainly looks very mechanical and business-like, and is a source of economy in fuel, well worthy of more consideration here.

The power company was started upon the belief that there was a great need for a cheap public supply of power, and that in a

large city most users of power required power intermittently, and therefore it was expensive to produce it themselves, so that there would be elements of great economy in a public supply, with also many attendant advantages, such as doing away with boilers, fuel storage, etc., and economizing in valuable space.

The financial success of the company, and the continued rapid growth of the number of consumers, proves the ideas of the promotors to have been very sound. The pipes in the public streets are laid at the company's expense, and service pipe charged to the customer. The quantity of water used is registered by a meter, so that the cost for power is exactly proportional to the amount of work actually performed. Several cases, where the public supply has superseded other methods, have given a saving of over 30 per cent.

Upon looking over the whole field, we see that there are a great many cases where the distribution of power, by the means of hydraulics, is attended with many very considerable benefits, be it simply in a large shop or industrial establishment, or as a public supply in a city. And I think that it may not be long before we see a more extended awakening in the country to the particular advantages of the system and the special applications that can be made.

XX.

THE PRESENT SITUATION OF THE INTEROCEANIC CANAL QUESTION.

By J. Foster Crowell, Active Member of the Club.

Read February 6th, 1886.

This paper, although written for Engineers, is not intended to present the subject from an engineering standpoint. Incidentally to a proper understanding of the conditions which now surround the problem of Interoceanic Communication, it will be found necessary to refer briefly to the diverse engineering features which distinguish the several projects that are before the world, but the primary purpose of the writer is to set forth the summation of

what has been accomplished toward the final determination of the question, and to consider, from the standpoint of the Publicist, the different claims to merit of the rival undertakings, by which he refers, of course, to the Sea Level Canal, under construction at Panama, the Slack Water system, proposed at Nicaragua, and the Ship Railway scheme, across the Isthmus of Tehuantepec.

The process by which the attention of the world has been concentrated upon these three lines of communication, has been the process of rejection. It is not necessary to here enumerate the multifarious projects which, during a period of more than three hundred years, have been put forward; it would, in fact, be impossible. Scarcely a single river or estuary opening into either ocean, from the northern limits of Mexico to the southern borders of New Granada, has not at some time or other been made the basis for some scheme of canalization.

But though surmise and misrepresentation had been so rife, and though many prominent and able geographers and men of science for so long had sought the proper solution, down to the middle of the present century nothing definite was known of any line. The construction of the Panama Railroad, and the establishment of the Central American Transit, in Nicaragua, revived interest in the question, and in 1851 and '52 an American Engineer, Oliver W. Childs, made a most valuable and accurate survey for a Canal at Nicaragua. International comities, however, combined with other considerations, prevented the consummation of this plan, and the civil war in America occurring, the matter laid dormant until some years after its close.

About 1870 the United States Government decided to proceed to the determination of the best site for a canal, and in order to arrive at an impartial and reliable conclusion, fitted out three distinct exploring expeditions, under military control of the United States Navy, and accompanied by Civil Engineers. Several years were consumed in exploring all the prominent routes, and in surveying such of them as were not palpably unsuited.

The Darien, San Blas, Panama, Nicaragua and Tehuantepec lines were thoroughly examined, and full reports were published. The reports were, by authority of Congress, referred to a Commission, consisting of one representative each from the Army, Navy,

and Coast Survey, who, after due consideration and a personal examination of some of the lines, by other army engineers selected by the Commission, reported in favor of the Nicaragua route.

It was then considered that the question of choice was disposed of, as far as the United States, at least, were concerned.

Without referring to the details of the several plans, it may be mentioned that the Darien line was rejected, among other reasons, because it involved a tunnel $2\frac{1}{2}$ or more miles long, sufficiently wide and lofty to accommodate vessels (the portal of the tunnel being in a cut 225 feet deep, which cut extended a distance of 48 miles, with a maximum depth of 245 feet, and an average of 90 feet); the San Blas route because of insuperable disadvantages of climatic and physical character; Panama, because of scarcity of water at Summit Level (a canal *a niveau* was not then seriously considered), while at Tehuantepec the excessive length, extreme lockage (732 feet), and the necessity of an immense feeder to the summit level, placed the duration of passage and the cost at figures too high to be considered.

By the process of rejection, then, the Nicaragua line was selected, but not alone to that was its selection due, for it proved to be admirably adapted in all the great essentials for slack water purposes, possessed unquestioned climatic advantages, and passed through a magnificent country, as yet scarcely peopled, and undeveloped, but full of vast opportunities. In fact, had it possessed good harbors, hardly a single objection could have been raised. The lack of harbors was not, it is true, a serious obstacle, but it was a formidable item in the estimate of cost. (This will be again referred to.)

The writer was engaged during the years 1872 and 1873 upon the exploration surveys and location in Nicaragua, and upon the subsequent preparation of the report and estimates submitted in 1874. He has also twice crossed the Isthmus of Panama, and spent some time in a visual examination of its topography.

After the report of the mixed commission before referred to was submitted to the President, in 1876, nothing further was done of any note, until 1879, and no advocates came forward for any other project; doubtless the business depression consequent upon the panic of 1873 contributed to this inaction.

In 1879, however, De Lesseps appeared for the first time upon the scene, as a promoter of a scheme which, at the outset, seemed designed simply and solely to provide with a vocation a young French officer whose star had gone down with the Empire. This was Lucien Bonaparte Wyse, who had secured a concession for building a canal on the abandoned and worthless San Blas route. It is said that De Lesseps was induced to this course by reasons of a sentimental nature, but be that as it may, it is a fact that he took up the San Blas scheme, and called what is known as the "Paris Congress," with the intention of having that route adopted. This Conference was composed of representatives of various countries, among whom were Sir John Hawkshaw, the noted English Canal Engineer; Dirks, the Government Director of Canals, in Holland, and other experts.

Mr. Menocal, Chief Engineer of the Nicaraguan surveys, and Commodore Ammen, under whose general direction the expeditions of the United States had been sent out, represented the United States. They presented full maps, profiles and detailed estimates for the Nicaragua line, and the experts named above, as well as many other members, pronounced in favor of this route, and San Blas was not even considered. At this juncture the "Panama Canal *a niveau!*" was presented to the Conference by De Lesseps, based on no surveys; vouched for by no engineer who had ever seen Panama, and over the protest of American, English and Dutch representatives, was adopted by a majority vote, with great French enthusiasm. An "estimate" was presented bearing necessarily no relation to the actual work to be done, amounting to about $250,000,000, and forthwith a company was formed; urgent efforts to secure funds in this country and in England, by the French Company, failed, although an American interest was formed, and in order to secure subscriptions in France, this estimate was cut down twice successively to $135,000,000. We are now told by De Lesseps, after several years of work on the Canal, that that amount is nearly or quite exhausted, and he asks $120,000,000 more, and "the end is not yet."

As to what work has actually been performed to date, reports conflict. Reports from the Canal Company are rosy, and the American contractors send home encouraging statements; this

was ever the way with companies and contractors. On the other hand, Dr. Rodriguez, a most intelligent and careful observer, has written and printed a book which, if mainly correct, would make the final completion of the Canal as problematical as it has ever been. A personal friend of the writer, an Engineer of prominence (whom he does not name because he has not had time to obtain his permission so to do), and a gentleman of undoubted accuracy of statement, spent a week in May, of last year, upon the small portion of the entire length which at that time had had any work performed upon it. (About four miles out of seven of dredging in alluvial deposit partly done, and about four miles out of thirty-five of the heavier, not the heaviest excavation commenced).

He made careful notes of the progress of the work in detail, and computed an approximate estimate, which gave the total amount performed at not more than five per cent. of the requirement; at that time the Canal people admitted the expenditure of $80,000,000, but such a large portion of that sum was for plant, railroads, hospitals, dwellings and barracks, that the amount of work was not justly represented by it. Making careful allowance for that, however, and checking the figures by applying the prices which the work was then costing, to the total amount to be done, he reduced the accomplishment to an equivalent of about thirteen per cent. of the finished work, which would cost over $600,000,000. It is fair to assume that as the work develops, prices may be decreased (for it is notorious among the initiated that it is now being done in a most wasteful manner), and that the entire expenditure may not exceed $500,000,000 if it continues. Another American Engineer, who has more recently visited the works, and who has long been professionally engaged in Central America, makes a statement which throws almost the same degree of doubt on the completion of the undertaking.

The Atlantic and Pacific Ship Railway scheme is the successor, in a commercial sense, to the abandoned project for the Tehuantepec Canal: it is located in the same region and has the same termini. It has been brought forward as a substitute for the Canal. It forms a striking illustration of the power of the engineer to set at naught the obstacles of nature, and is, as a concep-

tion, most admirably contrived, and beautifully adapted to its object, as probably all who have examined the plans and model will agree. Our valued fellow-member, Mr. E. L. Corthell, has recently issued a very exhaustive description of the system, and last year exhibited and explained the model before the Franklin Institute, so that it is not necessary in this paper to speak of its features in detail. So far as known to the writer, the Ship Railway scheme has not yet received the full measure of support needed to establish it as an actual undertaking.

This is also true, and perhaps in a greater degree, of the Nicaraguan project, which, nevertheless, has not been and is not now without its earnest promoters, who, undeterred by the prospects of its rivals, have almost succeeded in fairly launching it.

It will be remembered that at the close of the last administration, a treaty with Nicaragua, providing for the Canal, was under consideration. This was withdrawn by the present administration, and the matter has rested until now, when renewed efforts are about to be commenced.

Amplified surveys have meanwhile been made by Menocal, in 1880 and 1885, which, in combination with the advance in industrial resources since 1873, have enabled him to greatly modify and improve the first plan adopted, and it has recently, in its perfected form, been presented anew to the attention of the engineering world. We may then state of the three projects the following propositions:

1st. At Panama is the only feasible site for a Sea Level Canal; and such treatment is the only feasible one at that place.

2. That Nicaragua is the only practicable site for a slack-water system (for a canal with locks), and that it is pre-eminently adapted by Nature for such an use.

That there are no obstacles, in an engineering sense, and no physical drawbacks that need deter the undertaking.

3. That the Ship Railway, as a mechanical contrivance, has the endorsement of the best authorities, and may be admitted to be the *ne plus ultra* as a means of taking ships from their natural element and transporting them over the land.

4. That none of these plans has as yet advanced sufficiently far to warrant our considering its completion as beyond doubt.

5. That, as the additional sum now asked for by De Lesseps (even if sufficient) to complete the Panama Canal, is greater than the estimated cost of either the Nicaragua Canal, or the Ship Railway,* it would be economical to abandon the Panama Canal, and the money sunk in it to date, unless its location and form possess paramount advantages for the commerce of the world.

We may therefore profitably consider the relative merits of the three lines from four points of view, without regard to the past.

1. Geographical convenience to commerce.
2. Adaptiveness to all marine requirements.
3. Political security.
4. Economy of construction and operation.

1. As to geographical convenience. If we consider only the needs of the United States, commercial and military, the most northern line is the most favorable, and this needs no demonstration; considering the interests of the direct through commerce between Europe and Australasia, Polynesia, and the Asiatic Pacific ports, the same is true.

To vessels to or from Europe and the East, *via* West Indian ports, forming a very considerable part of the present and future marine interest, the advantage disappears, and so also to vessels from either side of the Atlantic, bound to western South America, (and who can estimate the future of this trade when the Isthmus is pierced?)

There is then little to choose in this respect between Tehuantepec and Nicaragua, but either is immeasurably superior to Panama.

2. Adaptiveness to universal marine requirements.

The interoceanic communication must be like the ocean highway, and fitted to receive any craft, from the 10,000-ton iron-clad cruiser down to the smaller class of wooden coasters. It must be

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* In Mr. Corthell's pamphlet: "*The Atlantic and Pacific Ship Canal,*" January, 1886, the probable costs given for these three projects are as follows:

Panama,	$400,000,000
Nicaragua,	200,000,000
Ship Railway	75,000,000

But Menocal's revised estimate for Nicaragua, at $65,000,000, is not to be set aside; Mr. Corthell quotes Major McFarland's figures, but McFarland never made a survey; the data of the Nicaragua surveys are exceptionally accurate.

ready at all hours to receive anything that comes, and as it comes, and deliver it surely, and safely, and quickly at its other terminus. It must be secure from every kind of sudden injury. It must have reserve capacity, and be of ample measure to accomodate traffic in both directions, without conflict. It is not to grow up with the trade, but to be provided at the outset, as far as human foresight and appliances can reach, for the vast processions of the ships of the future.

The Suez Canal is to be enlarged, after a service of sixteen years. Panama is barely wide enough for present requirements, and its enlargement would be nearly impossible and stupendously costly; it may do for the present, if completed; it cannot serve the future. It is the varied character and incalculable dimensions of future traffic that casts the grave doubt over the Ship Railway. That, it is true, can be doubled, or tripled, in tracks, but can the equipment be provided and kept in service to meet the needs of all classes of vessels of peace and of war? And can the turntable and shunting system be relied upon, day in day out, to transport quickly and surely the immense concentrated weights; it is the movement of the traffic, and not the lifting and supporting of the ships, that will test the system, and even the beautiful application of mechanical force, which it evinces, may be powerless to insure the high grade of service which is an absolute necessity.

In contemplating the methods proposed for conducting these titanic movements, it is impossible to lose sight of the great gap that intervenes between the point of highest attainment, so far, in the art of handling trains on railroads, and that at which the Ship Railway must begin its operations. Consider, for instance, the simple placing in proper position upon the turntables, of a vessel weighing, say with cargo, not more than six thousand tons; of the coming off with promptitude and certainty, to take the open siding, and backing on again with equal celerity, after the passing ship of perhaps twice, or perhaps half the weight, has been taken through the table with the same difficulties; and so in most other functions of the ship railway, which must be repeated many times per day.

This comment is not meant for adverse criticism, but merely

to indicate the tremendous task which the Ship Railway would have placed before it at the start. That means cannot be devised to overcome such difficulties, it would be folly to predicate, but the difficulties are there, and we are not yet informed how they are to be removed.

But admitting that in due course of time they could be eliminated by appliances superior to any yet devised, would the Ship Railway even then, no matter how perfect in its working, in any sense be superior to the water way, designed as the Nicaragua Canal is, in its later form.

By a single dam, near where the San Carlos River enters the San Juan Valley, a distance of 120.99 miles, consisting of 64.54 miles of river and 56.45 miles of lake, will be rendered available for unrestricted use by all vessels under their own power at full speed, excepting a length of 24 miles between the lake and Toro, where large vessels would be confined to a bottom width of 125 feet. By the prolongation of this lake summit level through the divide toward the Pacific, a further distance of 7.95 miles is secured, and from the San Juan Valley proper to Lock No. 3 (toward the Atlantic) is another stretch on the same level of 16 miles, making a total of summit level of 144.8 miles.

Of the remaining distance between the oceans, 12 miles are to be dredged through alluvial deposits, and 1.4 miles are in the Buto Basin, leaving only a length of 12.6 miles, wherein are to be encountered the 7 locks in the entire passage. Candidly speaking, this distance, divided into one run of 5 miles on the Atlantic side, and another run of 7.6 miles on the Pacific side, comprise the only parts of the canal where all steam vessels could not make the same speed with their own power, as they could, say upon the Hudson River, excepting the 24 miles stretch. And there is room enough, and to spare, for the body of water on the summit level is practically an inland lake, nowhere narrower than 1000 ft., with a sufficient depth for the greatest draught vessels, and at the widest part 45 miles. We then may in truth contrast the difficulties of *all* the stretches of canal proper, an aggregate length of 40 miles, with lockage of 110 ft. up and down, with the difficulties of taking ships out of the water, and transporting them over the land for 134 miles, a distance about equal

to that between Harrisburg and Altoona, ascending and descending in that distance an elevation of 742 ft.

Now as to the Harbor Question:

At Nicaragua harbors must be prepared. Nature was lavish at Greytown, and provided a sheltered roadstead, a mile or more in width, but the mischievous act of an idle human hand destroyed it. To restore it, would now be almost impossible; but to create one sufficient for all purposes is a mere question of dollars—a good many, it is true, but they are included in the total estimate of cost.

At Brito, on the Pacific, breakwaters may be necessary, but the sea section of the canal will be a basin sufficiently wide for harboring vessels awaiting transit.

Political security:

It is quite evident that there is no political security for the Canal at Panama, that is for American use of it. If completed it will not be, it cannot be, by private subscription. De Lesseps is now on his way to Colon with his friends, in order to carry back to France such favoring accounts, as will induce his Government either to give direct financial aid, which it recently declined to do, or to sanction a lottery, by which to raise the funds.

Were France to assume control, the Canal might become a *casus belli*, or our rights might be surrendered as not worth a struggle, which of course might cost more than many canals, or ship railways either.

At Nicaragua it is already sufficiently well ascertained that the United States can, if we so choose, make such terms as shall not only secure our use of the canal, but will enable us to maintain the Monroe Doctrine in reality, when occasion shall arise.

At Tehuantepec there would be no reasonable doubt of security, but we should first have to annex a part of, or coerce, Mexico, in order to render our rights to it perfect.

The advantage, politically, clearly lies with Nicaragua.

As to economy of cost and operation, leaving out Panama: Probably, unless one interest were to attempt to choose between the other two, and have all the data at command, it would not be possible to actually determine these points at this time.

Corthell's estimate for the Ship Railway (134 miles) is

$75,000,000, Menocal's for Nicaragua is $65,000,000; and by the ethics of our profession, we are bound, in the absence of other light, to accord that each is entitled to the high degree of confidence which their professional standing and large experience warrant.

In concluding, the writer wishes to emphasize the fact, that this all important question is still an open one, of which the future need of our country justifies and demands the most searching scrutiny, and, moreover, that our interests, and the interest of mankind require that before this century closes, the best possible pathway between the Atlantic and the Pacific shall be open to the navies of the world.

QUESTIONS.

Pursuant of the recent suggestion of Mr. W. H. Ridgway, Member of the Club, several Questions have been submitted for answer or discussion.

No. 1.

December 19th, 1885.

Suppose a shaft, sunk to a depth of 75 or 100 ft. through a somewhat broken rock, be divided into two compartments, 10 ft. by 10 ft., and 5 ft. by 10 ft., in area, respectively; the shaft timbered tightly with planks and the only communication between the two compartments being at the bottom. Why is a strong *upward* current of air experienced in the smaller?

These were the conditions in a shaft in a mountain some 10,000 ft. above sea level. There was no steam or other artificial heat at the bottom, nor was the temperature in the shaft very different from that of the outside atmosphere.

Answers.

L. Schutte, January 16th, 1886:—I submit the following as a possible solution of the above question.

Assuming a plain shaft without a partition, and that the temperature of the ground surrounding the shaft be somewhat higher than the outside atmosphere (which no doubt it is at certain

seasons or parts of the day), and further assuming a free admission of air at the bottom, then no doubt an upward current will take place.

As the circumference of the shaft multiplied by its depth may be considered the heating surface, it follows that a smaller shaft can have a larger heating surface in proportion to its area, and, therefore, a proportionately stronger current will occur in the shaft of smallest area.

This would apply to the above question:

Heating surface of shaft $A = 10 + 10 + 10 \times$ Height
" " " " $B = 5 + 5 + 10 \times$ Height

	A		B
or proportion of heating surface	30	:	20
" " Area =	2	:	1
proportion of strength =	15	:	20

or in other words, *there is one-third more of proportionate heating surface to induce the upward current in the smaller shaft B*, while the *speed* of the upward current in the small shaft will be twice that of the down current in the larger, simply due to their proportion of areas.

James Christie, January 16th, 1886:—A stream of air directed across the orifice of a tube, induces a current through the tube, as illustrated in the ordinary "atomizer," used for spraying perfumes, etc. The smaller the tube the more efficient this action, with an impelling current of given intensity. In fact, if the tube exceeds certain dimensions, the cross-current may be deflected downward into the tube. I think the atmospheric movement across the end of shaft would account for the phenomena, and it is rarely, if ever, that there is not some breeze. It could be demonstrated by observing if the ascending current is most active when the wind is highest.

No. 2.

December 19th, 1885.

a. What proportion of piston area should area of air inlet and outlet valves be on a blowing engine with a stroke of 48 ins.; cylinder, 54 ins. diameter; maximum speed, 30 revolutions per minute; blast pressure, 25 lbs. per sq. in.

b. Also, on a blowing engine with a stroke of 60 ins.; cylinder, 70 ins. diameter; maximum speed, 40 revolutions per minute; blast pressure, 15 lbs. per sq. in.

No answers have been received to this Question.

DWIGHT EDWARD PIERCE

Was born in Ansonia, Connecticut, in May, 1854, where he lived until 1865, when, with his parents, he removed to New Haven, Conn. He was always a studious boy, and at an early age evinced a strong desire for a liberal education, and every facility which his parents could command, and his own pushing determination could devise, was brought into play for the accomplishment of his purpose.

He went through the usual course at the High School, in New Haven, afterward entering the Hopkins Grammar School, where he graduated, and then entered the Sheffield School of Yale College, from which he graduated in 1875, with honor, the second in his class.

Immediately after his graduation he was appointed Instructor in the Hopkins Grammar School, where he remained until the spring of 1877, when, through the recommendation of Professor A. J. Du Bois, then of Lehigh University—now of Yale College—he was appointed Instructor of Mechanical Engineering in Lehigh University; and during the winter of 1877–'78 he performed not only the duties of Instructor, but Professor also, Prof. Du Bois having removed to New Haven. At the close of the College year, in 1881, owing to ill health, he resigned, and became the head of the manufacturing firm of D. E. Pierce & Co., which is now the Lloyd Valve Co., of Bethlehem, Pa., where for several years he showed his large capabilities and energy as a business man.

The sudden death of his wife, in November, 1883, was a blow from which he never recovered, and he felt that he could no

longer remain in Bethlehem, and he resigned his position with the Lloyd Valve Co., in June, 1885.

In August of this year he accepted the position of Business Manager of the Wyoming Valley Manufacturing Company, and feeling the need of a few weeks' vacation, went on August 15th to Bristol, R. I., where he was taken with typhoid fever, and died September 1st, 1885, and was buried by the side of his wife, in Evergreen Cemetery, New Haven, Conn.

COL. JAMES WORRALL,

Died April 1st, 1885, was born in the City of Limerick, Ireland, on the 12th day of January, 1812. His father, John Worrall, having suffered losses in business by which his fortune was impaired, felt compelled to seek elsewhere a home for himself and his large family. He therefore immigrated to America, where he died, in Philadelphia, in 1845. James, the eldest child, found employment in the bookstore of Carey, Lea & Co., of Philadelphia, and after remaining there some years, secured a position in an engineer corps, at work more congenial to his tastes. On attaining his majority, in 1833, he assisted in making the surveys and maps of the St. Lawrence Canal, between Prescott and Cornwall, and soon after became a member of the engineer corps on the Chesapeake and Ohio Canal. His services were next employed in surveys made in 1835, under Colonel Schlatter, for a railroad from Trenton to New Brunswick, N. J. A few years later he assisted Hother Hage, in making explorations and surveys from the vicinity of Harrisburg across the southern line counties of Pennsylvania to Pittsburgh. He had charge of that portion of the line extending from Bedford across the Allegheny Mountains to Laurel Hill. The knowledge of the topography of Central Pennsylvania acquired during these explorations, enabled him to point out a feasible route for a railway through that region; and modern engineers have found their

labors lightened by adopting his recommendations. The time, however, for building great lines of railroad had not then arrived, and the Colonel was obliged again to turn his attention to lines of water navigation. His next important engagement was on the Erie extension of the Pennsylvania Canal, where he served as Principal Assistant to William Roberts. In 1844 he was concerned in railroad and canal contracts on the Canada border.

In 1850 he was appointed Chief Engineer of the Union Canal, and under his direction an enlargement of the Canal was made, so that boats of greater tonnage could be floated. While thus employed, the first railroad connecting the Cornwall ore hills with the town of Lebanon and the Canal—called the North Lebanon Railroad—was constructed, under his direction as Engineer.

The destructive floods of 1862 having greatly damaged the Canal, Col. Worrall was authorized to take charge of the engineers appointed by the Company to make a thorough inquiry as to the causes of the floods and the resultant destruction, as well as to the effects thereof on the "Branch Canal" and the "Western Division" of the works. His report, made in 1863, contained a full exposition of the subject.

The Colonel was so firmly convinced of the practicability of a southern route to Pittsburgh, that he became a few years ago the leading spirit in the Sherman's Valley Railroad Company, a corporation created for the purpose of building a railroad from the Susquehanna River above Harrisburg to Pittsburgh, over the ground he had explored in 1838. Sufficient capital could not be enlisted to build the road, but he kept the charter alive, and after disposing of it to the South Pennsylvania Railroad Company, he had the proud satisfaction of knowing that the work of construction had actually been commenced on the line he had long advocated as being the shortest and easiest of gradients of any projected between Harrisburg and the Ohio.

Under an Act of the General Assembly of the Commonwealth, approved May 8th, 1876, a commission was appointed to act in conjunction with a commission appointed by the State of New York, to re-survey the boundary lines between the two States; and an Act passed May 18th, 1878, authorized another commission to cause the lines between this State and the States of Ohio and West Vir-

ginia to be re-surveyed. Col. Worrall was appointed on both commissions, and was chosen chairman of both. He discharged his duties on these commissions with characteristic fidelity.

The Ohio survey was finally reported upon about two years ago; but the Colonel did not survive the completion of the work on the other lines.

In 1866 he was appointed Fish Commissioner for Pennsylvania, and subsequently, on the creation of the Board of Fishery Commissioners, he served the Board as its Actuary. In 1868 he received an appointment from the Surveyor-General to make a survey and an estimate of the expense of reclaiming the land in Crawford County, known as the Conneaut and Pymatuning marshes. This work was intelligently performed, and its results were embodied in a report made to the General Assembly.

The Assembly which adopted a coat of arms for the Commonwealth, during the stirring days of the Revolution, neglected to cause an official emblazonment of it to be placed in the State archives, and the innovations made during the century succeeding —suggested by the fancies of engravers and others—brought about such a wide divergence from the original, as to require an authoritative correction. A commission was appointed in 1874 to restore the original. This commission sought the aid of Col. Worrall, and he entered upon the work with great enthusiasm. A report embracing the results of his own and his colleagues' labors, and accompanied with the restored arms, properly emblazoned, was made and placed on file in the office of the Secretary of the Commonwealth.

About five years ago, under authority of the United States Government, he prepared from his own explorations and the investigations of other engineers, an elaborate report on the practicability of restoring water communication between the Atlantic seaboard and the Ohio River. The report was accompanied with maps and plans illustrative of the proposed improvement.

In various other public improvements his professional services were engaged from time to time.

Amid the cares of a busy life, Col. Worrall found time to devote attention to devising a method for the relief of the River Thames, at London, of its accumulated sediment; and in a re-

port on the subject he made some bold, practical suggestions. The improvement of the navigation of the Ohio River also received his consideration. For this improvement he recommended the "Jetty" system.

Through the Austrian Consul, in 1882, he was invited to contribute to a work undertaken by the Chief Engineers of the Austrian Government on canals, railroads and magnetic telegraphs. To him was particularly assigned the canal system of Pennsylvania; and so well was his duty discharged, that it elicited from the Imperial official named a highly complimentary acknowledgment, together with a copy of the completed volume, containing that portion relating to the "United States of North America."

Col. Worrall was tall in stature and of commanding presence. His mind was active and well stored with knowledge acquired by careful reading, and experience gained in long years of professional service. While taking an interest in the events occurring in the world around him, engineering problems and achievements received his most earnest attention. In conversation he was entertaining and instructive; in social life unexcelled in courtesy; and in the line of official duty, attentive, exact and faithful.

J. Simpson Africa, *Chairman,*
L. M. Haupt,
A. E. Lehman,
} *Committee.*

ANNUAL REPORT OF THE SECRETARY AND TREASURER.

For the Fiscal Year 1885.

Presented, January 9th, 1886.

To the Officers and Members of the Engineers' Club of Philadelphia:

Gentlemen:—I have the honor to present the following statement of the receipts and expenditures for the fiscal year from January 10th, 1885, to January 8th, 1886, both inclusive.

Howard Murphy, Secretary and Treasurer, in account with
The Engineers' Club of Philadelphia.

Dr.

Balance on hand Jan. 9th, 1885,			$121 95
Initiation fees—Active Members,		$360 00	
" " Associate "		30 00	390 00
Dues, 1881, Resident,		1 00	
" 1883, Non-resident		5 00	
" 1884, Resident,	54 25		
" " Non-resident,	22 50	76 75	
" 1885, Resident,	1755 00		
" " Non-resident,	652 50		
" " Associate,	52 50	2460 00	
" 1886, Resident,	600 00		
" " Non-resident,	155 00		
" " Associate,	15 00	770 00	3312 75
Subscriptions to Proceedings,		15 00	
Sales of Proceedings—Members,		19 91	
" " " Non-members,		12 00	46 91
Advertisements, 1882,		12 00	
" 1883,		42 00	
" 1884,		474 00	
" 1885,		306 00	834 00
Key deposits,			4 75
Sundries,			46
			$4710 82

CR.

Expense at Rooms 1523 Chestnut St., Jan. 1st to June 30th:			
Rent,	$325 02		
Gas,	11 22		
Janitor,	12 00		
Laundry,	1 70	349 94	
Expense at House 1122 Girard St., July 1st to Dec. 31st:			
Rent,	500 00		
Gas, Oct. 16th to Nov. 18th,	7 68		
Coal oil for janitor,	1 30		
Coal—Small Stove, $36.75; Egg, $21.00,	57 75		
Janitor, Aug. 6th to Dec. 31st,	72 58		
Sundry,	40	639 71	
Ice,	20 75		
Sundry expenses of quarters for year,	6 52	27 27	1016 92
Salary of Secretary and Treasurer,		1000 00	
Clerk,		103 90	1103 90
Proceedings—Vol. IV, No. 3, balance,		46 00	
" " " " 4, "		156 25	
" " " " 5, "		402 62	
" " V, " 1,		284 11	
" " " " 2,		312 78	1201 76
Reference Book,			55 40
List of Members, March, 1885,			59 29
Constitution and By-Laws,			18 49
Printing and Stationery:—			
Notices and Records and Elections,		246 87	
Miscellaneous,		93 86	340 73
Postage,			242 88
City Directories,			6 50
Messenger, telegraph and express service,			7 98
Expense of appeal to Secretary of the Treasury as to liability to Customs duty,—brokerage, etc.,			20 39

Packing and shipping of imported pamphlets, . .	9 01
Customs duty, prior to decision of free entry, . .	1 08
Key deposits returned, ...	1 75
Christmas gifts ordered by Board, ...	15 00
Sundries, ...	34
Cash on hand January 8th, 1886, ...	609 40
	$4710 82

The following are the closely approximate assets of the Club, in addition to its library and furniture.

Cash balance Jan. 8th, 1886, ...	$609 40
Due from Members to date, initiation fees and dues, .	412 14
Due for advertisements, ...	445 00
Due for Proceedings, etc., ...	31 93
	$1498 47

The only liabilities of the Club are for gas used since Nov. 18th, for which bill has not been presented; and less than $5 for printing now in progress; or, in all, about $15. Our net assets are, therefore, about $1483.

However, to properly compare these with those of last year ($825), the advance dues should be subtracted from each; which would give $781 for last year, and $728 for this year. This difference of $53 looks, by itself, like a decrease of prosperity, but by no means is it when considered with the fact that our actual expenditures during this year were $706.37 in excess of those of last year.

MEETINGS.

Regular	8
Business	5
Special Business (prior to the adoption of the new By-Laws)	4
Total	17

The Board of Directors have held 13 Business Meetings.

ATTENDANCE.

	1885.	1884.
Members, total, ...	712	604
" average, ...	42—	34—
Visitors, total	46	72

Continuing the Membership Table from my last Report (Vol. IV, No. 5, p. 385) we have

	HON.	COR.	ACT.	ASSOC.
Membership at end of fiscal year 1884,	3	5	363	0
Additions, ...			73	6
			436	
Transferred from Active to Associate,			2	2
			434	
Deceased, ...			4	
			430	
Resignations, ...			7	
	3	5	423	8

The net increase of Membership has been $18\frac{3}{10}$ per cent.

The residence of our Active Membership is now as follows:

Philadelphia, ...	226
Pennsylvania, outside of Philadelphia,	101
New York, ...	29
Virginia, ...	13
New Jersey, ...	9
Delaware, ...	4
Colorado, ...	4
Massachusetts, ...	3
Maryland, ...	3
Minnesota, ...	3
Illinois, ...	3
Missouri, ...	3
Connecticut, ...	2
North Carolina, ...	2
Georgia, ...	2
Rhode Island, ...	1
Alabama, ...	1
Texas, ...	1
Michigan, ...	1
Indiana, ...	1
Ohio, ...	1

Iowa,	1
Kansas,	1
Arkansas,	1
Arizona,	1
District of Columbia,	1
Austria,	1
Japan,	1
New Zealand,	1
Brazil,	1
United States of Colombia,	1
Total,	423

We have therefore 226 Active Members, or $53\frac{4}{10}$ per cent., residing within, and 197, or $46\frac{6}{10}$ per cent., residing without, the city limits.

The deaths have been four: David Hudson Shedaker, and James Worrall, at the end of long and useful lives; Theodore Bergner, in the prime of life, and Dwight E. Pierce, just as he had entered upon well-deserved prosperity. It can be honestly said that all these were remarkable men, and that their loss to the Club is a loss to be felt.

The following original papers have been read before the Club during the year:

Phœnixville Tunnel, Penna. Schuylkill Valley R. R., by M. Van Harlingen.

Sources of Pollution in Storage Reservoirs, by A. Harvey Tyson, with Discussion by C. G. Darrach and Dr. H. M. Chance.

Strengthening of the West Main Abutment of Chestnut Street Bridge, by J. Milton Titlow, with Discussion by Prof. L. M. Haupt, Howard Murphy, C. G. Darrach, Rudolph Hering, Dr. H. M. Chance, and the Author.

Construction of Street Railways in the United States, by Wm. Wharton, Jr.

Isthmian Transits, by P. C. F. West.

Latitude and Departure Method of Calculating Areas, by E. S. Hutchinson.

Water Works of Columbus, Ga., by Jacob H. Yocum.

Fast Passenger Locomotives, by T. E. Austin.

Connection of the Baltimore and Ohio R. R. with the Phila. and Reading R. R. through the City of Philadelphia, by C. W. Buchholz.

Stereographic Projection, by Prof. L. H. Barnard.

Sand Bag Embankment to Close Little Inlet on Brigantine Beach, N. J., by P. T. Osborne.

Relative Costs of Fluid and Solid Fuels, by James Beatty, Jr.

Repairs to the Conduit of the Philadelphia Traction Company, by Prof. L. M. Haupt.

A Cheap Cement Testing Machine, by P. F. Brendlinger.

Adaptation of Steel to Structural Work, by James Christie, with Discussion by Thos. M. Cleemann, Prof. W. H. Burr and the Author.

Specifications as Affecting the Dimensions of Iron Railroad Bridges, by Jno. S. Elliott.

Masonry Arches, by J. Foster Crowell.

Engineering; Its Achievements and Its Reward, by C. W. Buchholz.

The following Coutributions have been made to the Club Reference Book:

Scales of Maps (Revision), by Prof L. M. Haupt.

Table of Chains Reduced to Feet, by H. W. Clarke.

The Polar Planimeter, by John T. Boyd.

Table for Finding Ordinates to Circular Arcs, by S. P. Mitchell.

Questions upon the following subjects have been offered for answer or discusion:

1. Chimney Draft.
2. Piston Area in Blowing Engines.

The following Notes and Communications have been presented:

A Large Land Dredge, by J. C. Trautwine, Jr.

The Construction and Manner of Turning of the Large Hoisting Drums of the Calumet and Hecla Mining Company, by Chas. T. Thompson.

Mining Methods in Colorado, by H. A. Vezin.

The So-called Artesian Wells of New York, by Howard Murphy.

Diagrams for Determining Belts, Pulleys and Shafts, and for Cast Iron Cogs, by H. A. Vezin.

Recent Locomotive Construction, by Geo. S. Strong.

The Curtis & Wood Automatic Car Coupler, by John Wood, Jr., Visitor.

The Wernwag Bridge over the Schuylkill River, at Philadelphia, by P. T. Osborne.

Sewerage Work at Atlantic City, by James F. Wood.

The Beaumont Rock Drill, by Jones Wister.

The Air Brush, by Howard Murphy.

Purification of Sewage, by Kenneth Allen.

The Borup Coal Chute, by W. F. Newell, Visitor.

An Improved Protractor, by Kenneth Allen.

Pollution of the Upper Schuylkill, by Dana C. Barber, with Discussion by President J. J. de Kinder.

The Coventry Locomotive Boiler, by J. T. Boyd.

Appliances for Landing Mine Cars at the Top of Slope, by Walter C. Brooke.

An Instrument for Describing Arcs of Long Radii, by A. Marichal, Visitor.

The Albo-Carbon Light, by F. H. Bowen, Jr.

The Early Water Works of Philadelphia, by Rudolph Hering.

The New Croton Aqueduct, by W. S. Church.

Rack Rail Appliances for Railroads, by Geo. S. Strong.

An Appliance for Fastening the Floor Timbers of Highway Bridges, by A. R. Roberts.

Mitis Metal Castings, by P. Oestburg, Visitor.

A Movable Dam and Caisson Operating Truck, by Wm. H. Dechant.

Artificial Fuel, by Washington Jones.

The Forth and Tay Bridges, by Thos. C. Clarke.

Respectfully submitted,

HOWARD MURPHY, *Secretary and Treasurer.*

AMSLER'S POLAR PLANIMETER.

METHODS OF USING AS APPLIED TO THE AREAS OF IRREGULAR FIGURES AND INDICATOR DIAGRAMS.

JOHN T. BOYD, December 15th, 1885.

There are two methods of using the Planimeter; one when the needle-point or pole lies *outside* the figure whose area is sought to be determined; and the other when the needle-point lies *inside* the figure: the former being the method most generally used.

When the figure is too large to permit the tracing-point to traverse the entire periphery, it can be subdivided by drawing straight lines through it, and the contents of the several parts computed separately and added together.

Before using the instrument, see that the horizontal shaft of the rolling-wheel is in adjustment and revolves freely on its centres, also that the rolling-wheel does not touch the vernier, and that the radial-arm carrying the needle-point moves easily on its pin-connections. It is well to oil the centres now and then to reduce wear, and great care should be taken to prevent bending any part of the instrument, as its accuracy largely depends upon its freedom from injury.

The following facts should be remembered: the figures 0.1 *sq. ft.*, 10 *sq. in.*, *etc.*, engraved on the *side* of the sliding-bar carrying the tracing-point, have nothing to do with the *absolute* dimensions of the figure to be measured, no matter whether the needle-point lies outside or inside the figure; they merely show the value of the *unit* of reading.

If the area to be measured is drawn on a reduced scale, the *final* results in either method given further on, are to be multiplied by the *square* of the proportion which the scale bears to the full size of the area itself; that is to say,

if the scale is $\frac{1}{8}$, $\frac{1}{10}$, $\frac{1}{12}$, or even less, the *final* results are to be multiplied by 64, 100, or 144, etc., as the case may be.

The needle-point is to project but slightly from its socket, and be held in place on the paper by the small weight which accompanies the instrument, as the needle-point is to remain in one position during any one operation.

To find the Area of any Figure when the Needle-point or Pole lies *outside* the Figure.

Set the graduation on the *side* of the sliding-bar, corresponding to the unit of measurement in which the area is desired, whether in square feet, square inches, etc., to the line on the square-tube forming the bracket which carries the indicating-wheels, clamp the micrometer-slide and place the instrument on the paper.

Place the needle-point in such a position outside the figure that the tracing-point can freely traverse the outline of the figure.

See that the rolling-wheel travels on the same plane as the figure to be measured, and in case the drawing-paper is rough, a sheet of smooth paper can be so placed as to allow the rolling-wheel to roll on it in order to steady its motion, while the tracing-point is following the outline of the figure.

It is of no consequence whether the rolling-wheel is, or rolls, inside or outside the figure, provided it is on the same level; and see that the rolling-wheel, the needle-point, and the tracing-point touch the paper.

Select any point on the outline of the figure as a starting-point, set the tracing-point on said point, and read off the horizontal or counting-wheel, the rolling-wheel and the vernier, in the order here named: Suppose, for example, the counting-wheel shows 3, the rolling-wheel 67, and the vernier 4; the number will be 3.674; and here it is well to

state that the reading is *always** to be considered as a figure with three (3) decimal places, as also the figures on the *top* of the sliding-bar.

Note this reading, 3.674; and then follow the outline with ordinary care—the tracing-point being moved in the same direction as the motion of the hands of a watch (when the travel of the rolling-wheel will in all cases be an advancing one, owing to the needle-point being outside the figure), until the tracing-point returns to the starting-point —straight lines need not be followed along a ruler—then read off the counting-wheel, the rolling-wheel and the vernier, as before; and suppose the second reading is 8.159.

Subtract the first reading, 3.674 from the second reading, 8.159, the remainder is 4.485, which shows the figure contains 4.485 *units of reading.* Now depending upon the regulation of the sliding-bar, if the same is set for 0.1 sq. ft., the 4.485 units are to be multiplied by 0.1 = 0.4485 sq. ft. as the area of the figure measured on the paper; or if the sliding-bar be set for 10 sq. in., multiply the 4.485 by 10 = 44.85 sq. in.

The rule therefore is to *multiply the difference of the two readings by the number on the side of the sliding-bar, and this product gives the area of the figure*—which if drawn on a reduced scale must be treated as before mentioned.

In measuring large figures at one operation it sometimes happens that the zero on the counting-wheel passes the fixed index-mark on the bracket; then the second reading (in this case 8.159) should have added to it one more digit to the *left* (making it 18.159), before subtracting the first reading from the second, a digit being added for each entire revolution of the counting-wheel after the first revolution.

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* Exception. When using the Planimeter on Indicator Diagrams, the reading is considered as a figure with only one (1) decimal place.

To find the Area of any Figure when the Needle-Point or Pole lies *inside* the Figure.

Having set the desired graduation on the sliding-bar to the line on the square-tube, place the needle-point inside the figure in such a position that the tracing-point can freely traverse the outline—observing all the directions before given as to the other points in setting the instrument—select a starting-point, place the tracing-point thereon, note the reading of the indicating-wheels, follow the outline around and back to the starting-point, note the reading of wheels as before.

Now the needle-point being inside the figure, the travel of the rolling-wheel can be either advancing or retrograde —which must be ascertained by looking at the counting-wheel (it is in most cases an advancing motion).

If the zero-mark on the counting-wheel passes the fixed index-mark on the bracket, one more digit is to be added to the second reading if the motion of the rolling-wheel was an advancing motion; but to the first reading if the motion was a backward one.

In the first case (advancing motion) the first reading must be subtracted from the second reading, and the difference of the two readings is to be *added* to the figures engraved on the *top* of the sliding-bar at the point where it is set to the line on the square-tube, and this sum is to be multiplied by the figure on the *side* of the bar showing the unit of reading, the answer will be the area of the figure in units of measurement.

In the second case, viz.: if the motion of the rolling-wheel be a backward one, the second reading should be subtracted from the first reading in order to get the travel of the rolling-wheel. The difference of the two readings is then to be *subtracted* from the figure on *top* of the bar,

and this result is to be multiplied by the figure on the *side* of the bar, which will then be the area of the figure, which, if drawn on a reduced scale, must be treated as before mentioned.

Indicator Diagrams from Steam Engine and Pump Cylinders.

On some forms of the Planimeter are placed two steel points, one on top of the sliding-bar and one on top of the square tube forming the bracket. These points are to be used when it is desired to ascertain the mean pressure in pounds per square inch in steam engine and pump cylinders by indicator diagrams.

The diagram being fastened down on some flat surface, the Planimeter is set by taking the whole *length* of the diagram, measured on the atmospheric line, accurately between the steel points, and then clamping the micrometer motion to secure the bar and points from moving.

The needle-point is placed outside of, but in a convenient position, so that the tracing point will traverse the whole outline of the diagram.

Use the *outside method* described before, and having obtained the two readings; the first reading is to be subtracted from the second, which gives the average height of the diagram in $\frac{1}{40}$ths of an inch, which, when multiplied by the vertical scale of the diagram, will give the mean pressure in pounds per square inch.

In taking readings for diagrams, the readings are to be considered as figures having *one* decimal place.

Thus, if the first reading is 147.3 and the second 236.1, their difference is 88.8, which is the average height of the diagram in $\frac{1}{40}$ths of an inch, or $\frac{88.8}{40} = 2.22$ inches.

If using a "30 lb. spring" in the indicator, multiply the

2.22 by 30 = 66.6 lbs.; or, if a "40 lb. spring," 2.22 × 40 = 88.8 lbs. per square inch; and so on.

By a "30 lb. spring," "40 lb. spring," etc., is meant that for every inch which the pencil point of the indicator rises vertically, 30 or 40 lbs. per square inch steam pressure, depending on which spring was employed, has been used to raise the piston in the indicator; so that the vertical scale of the diagram is determined by the spring used at the time of taking the diagram, or card, as it is sometimes called.

NOTES AND COMMUNICATIONS.

THE COVENTRY LOCOMOTIVE BOILER.

Regular Meeting, October 17th, 1885.—Mr. John T. Boyd presented an illustrated description of the Coventry Locomotive Boiler, which, he said, is probably the latest novelty in locomotive construction.

It was built at the Brooks Locomotive Works, Dunkirk, New York, and placed on one of their standard 17 in. x 24 in. engines, with 61 in. drivers. The economy of the boiler as a steam generator has not been made public, but while in service on the New York Division of Penna. R. R. it has proved to be almost absolutely free from smoke and cinder discharging qualities. The boiler is of the straight-top return-tubular type, is made of Otis steel throughout, and is remarkable in having but two barrel-sections, excluding the smoke-box.

The stack is "behind instead of before," and is located over the front end of what might be called the upper crown-sheet, which forms the bottom of the back combustion-chamber, which is directly over the fire-box, the stack itself rising from top of boiler between the cab and dome. The crown-sheets are self-sustained by long stay-bolts opposing the pressure in inside of boiler.

Access to the back combustion-chamber is had by means of a man-hole in the rear-head of boiler, through which the exhaust nozzles and lift-pipes are put in position.

The lower, or 2-inch tubes, are arranged as in the ordinary locomotive, while the upper, or 3-inch tubes, are grouped around the dry-pipe as it passes from the dome to the "T" head in smoke-box.

In order to get the exhaust steam from the cylinders into the stack, side pipes provided with expansion joints after leaving the smoke-box, are placed outside of but close to the boiler-jacket, and enter the back combustion-chamber close to the base of the stack.

The throttle-lever is turned "upside down" to get a pulling motion to open the throttle, and the rod is forked to pass around the stack at its base, in order to reach the bridge-pipe at dome.

The steam-supply for injectors, air-brake pump, heater-cocks, cylinder-oilers, blower, etc., is brought from bridge-pipe in two pipes, one on each side of boiler.

The mud-ring in water-leg is shaped to take the curved sides of the back-head, and allow the outside side-sheets of the firebox to lie straight against the edge of the ring, thereby reducing "scarfing" the edges of the back-head to a minimum, if not dispensing with the "scarfing" altogether.

The boiler is 61 in. diameter, 23 ft. $4\frac{7}{16}$ in. long, and is of $\frac{1}{2}$-inch steel. The barrel contains 152 2-inch and 43 3-inch tubes, each 11 ft. $5\frac{1}{8}$ in. long. The firebox inside is 5 ft. 10 in. long x 34 in. wide, and crown-sheet about 4 ft. above grates. Total heating surface is about 1275 sq. ft. Weight of boiler alone is 23,000 lbs.

THE EARLY WATER SUPPLY OF PHILADELPHIA.

Business Meeting, November 7th, 1885.—Mr. Rudolph Hering read some interesting extracts from a *Report of the Committtee for the Introduction of Wholesome Water into the City of Philadelphia*, 1801, as follows:

The Committee for superintending the introduction of Wholesome Water into the City report, that from the nature of the business which they have been called on to direct, it has been impracticable, during its progressive state, to render as frequent and detailed reports to Councils as would otherwise have been agreeable. While the works were so circumstanced, that every part of them was daily assuming a new aspect, the difficulty of furnishing very minute and complete statements of the expenditures and condition of each department, must, in an undertaking so extensive, interesting, and novel, appear obvious to every one.

In addition to the information which has, from time to time, been laid before Councils, the Committee have now the pleasure of presenting a view of the subject, which they flatter themselves will be acceptable. It contains an accurate statement of the situation of the works on the first of October.

The Basin may be considered as completed, except as to the coping of the wall. It is entirely out of danger, and conceived to be sufficiently substantial to resist the utmost force of the waters in the most rigorous seasons. The coping may be finished before Winter, as part of it is already done, and preparations made for the completion of the residue. The whole cost of this article, so far as it has gone, is twenty-two thousand one hundred and seventy-eight dollars and thirty-three cents. The additional expense will be trifling.

The Canal which leads from the Basin and connects with the lower Tunnel is completed, except as to coping the wall and sluice. Stone has been collected for that use, and may be wrought and set at any time. There has been expended in digging, walling, and materials, on this object, three thousand four hundred and thirty-eight dollars and sixty-nine cents; besides which the Canal Sluice cost two thousand two hundred and sixty-four dollars and forty-three cents.

The Lower Tunnel wants nothing but an iron grating to render it complete. It cost six thousand nine hundred and twenty-one dollars and ninety-three cents.

The Lower Engine House is finished, so far as respects the purpose to which the engine is now applied. When the extra power shall be used for mechanical purposes, it will be necessary to complete the cellar at the north end; but this is rather a matter of concern to the contractor than to the corporation. This building was erected on a larger scale, and at a considerable increase of expense for his accommodation, and, whenever the extra power shall come into operation, this will form a fair item of charge against the party who may use it. The house cost eleven thousand one hundred and sixty-one dollars and sixty-four and an half cents. The stone for walling up the cellar is in readiness, and the doors and window-sashes nearly prepared to be fixed in their places. The Engine Well in this house cost nine hundred and fifty-two dollars and sixty-eight and an half cents. A small additional expense will be incurred in coping this well, and the pump-chamber adjacent to it.

The Upper Tunnel may require some pointing. In other respects it is finished, and cost twenty-six thousand one hundred and twenty dollars and fifteen and an half cents.

The Centre Square Engine House has already cost forty thousand five hundred and thirty-two dollars and seventy-one cents. It is not quite completed; but nearly all the marble is set or prepared, and may, together with the masonry, be finished this Fall. The carpentry is also in a state of great forwardness, and may be accomplished in the Winter. It is probable that, in addition to the sums which have been expended on this building, the marble mason will have a demand for about eight thousand dollars, for marble prepared but not yet measured. The permanent Reservoir, ordered

by the Committee to be of timber, is now fitting up in this house, and included in the expense. It will be ready to receive the water in the course of two or three weeks.

In the Distribution much difficulty has been experienced on account of the leakage of the pipes of conduit, and the devices connected with them. Most of those difficulties have been surmounted. Perseverance, and that knowledge which is only to be acquired by experience, will, it is hoped, finally prevail over the rest. In the opinion of some gentlemen, iron has been thought to be the best material for pipes; and, in order to procure a fair experiment, the Committee have obtained a few feet, which are now at the Centre Square, and appear to be well cast. Directions have been given to place these pipes, fourteen in number, each six feet long, under the greatest pressure of the water, in order to prove a method of securing their joints, which, it is supposed, will be substantial, and cheaper than the common mode.

The plan of the Hydrants that were first used has been wholly rejected, and another, which answers better, substituted. Of the latter, thirty-seven are now fixed in different parts of the city, and six more are in readiness for the same use.

The number of private houses supplied with Schuylkill water is sixty-three, of which twenty-seven belong to applicants, and thirty-six to subscribers to the loan. Four breweries and one sugar refinery also draw their supply from the same source. Nor is there a doubt but the great and increasing value of the water, for culinary and other purposes, will induce a very general demand for it, whenever the distribution shall be more widely extended, and be in a more perfect state.

Under this head of expense is included the pipes of conduit, and all the devices attached to them, the distributing chest, and the descending main leading to it from the reservoir in the Centre Square Engine House. The whole expense now incurred is thirty-one thousand four hundred and twenty-two dollars and twenty-two cents. There are now laid twenty-nine thousand nine hundred and sixty-three feet of pipe in different parts of the city, and it is a very desirable object to have the distribution as generally extended the ensuing season as circumstances will allow, not only as it respects the increase of the corporate revenue, but the convenience and accommodation of the citizens. The impracticability of procuring suitable logs last Spring, prevented the Committee from laying as many as they could have wished, and as would have been advisable.

The Engines have cost the Corporation thirty-one thousand eight hundred and eighteen dollars and thirty-two cents, exclusive of nine hundred and forty-two dollars and eighty-one cents, paid for the frames on which they are supported. Hitherto they have operated well, nor can there be a doubt of their fully answering the purposes of the city.

The Committee have given directions for the immediate erection of two additional boilers, agreeably to the original design, to guard against any inconvenience which might arise from accidents to those which are in use. They are manufacturing at the expense of the contractor for the engines, and his account will accordingly be charged with all the moneys which may be disbursed in their completion.

The Engines cannot, in their present condition, pump three millions of gallons of water in each and every twenty-four hours; but they may, by an enlargement of the working barrels of the pumps, be easily made to throw up even a larger quantity; and the contractor is bound, whenever the Corporation shall require it, so to alter the engines that they shall pump the quantity required by contract.

* * * * * * * * * * * * * *

The Engineer, by special articles of agreement, was entitled to receive six thousand three hundred and fifty dollars as a full compensation for his services, on the completion of the work in all its parts. This sum he has drawn for, and it has been paid to him within about twelve dollars. It is proper in this place to observe, that he demanded one thousand nine hundred and twenty-five dollars more than his stipulated compensation, on grounds which the Committee deemed inadmissible. The demand was, therefore, rejected. The salary of John Davis, who has been with the Committee from the commencement of the undertaking, and whose employment as clerk of the works has been very essential and satisfactory, amounts to two thousand three hundred and thirteen dollars. And the salary of James Todd, the accomptant, an officer equally deserving and useful, has, during the same period, amounted to one thousand nine hundred dollars. And there has been paid to another person, as a salary, three hundred and seventy-two dollars and seventy-five cents.

Notwithstanding a distinct head of the several objects of expense has been carefully preserved, yet it has happened that expenses have been incurred, which, although chargeable to the whole, could not, with facility and clearness, be assigned in the proper proportion of the parts. Thus, there has been paid for scaffolding; shops, for the accommodation of the different workmen employed; lime-houses; fences; tools and utensils; including also all the wages paid to the carpenters, the sum of sixteen thousand three hundred and five dollars and twenty-nine cents. To the smiths, including expenses of erecting forges, cost of coals, iron, etc., two thousand three hundred and twenty-nine dollars and twelve cents. To men employed in sawing scantling, etc., nine hundred and thirty-seven dollars and sixty-six cents. For glass and other materials for the buildings, six hundred and sixty-nine dollars and seventeen cents. And for shingles, some of which have been used in both buildings, and some remain unused, five hundred and sixty-five dollars and forty-one cents.

The Centre Square has been partially levelled and planted with trees, with the view of affording an agreeable and useful place of recreation to the citizens. The expense attending this object amounts to one thousand one hundred and ninety-five dollars and eighty-two cents.

To the workmen liquor has been supplied to the amount of eight hundred and ninety-eight dollars and forty-four cents. To the marble mason there has been paid, on account of marble prepared but not measured, eight hundred and nineteen dollars and sixty-five cents. Some materials have been sold to individuals, who still stand charged, on that account, with one hundred and thirty-six dollars and eighty-four cents.

Other expenses have arisen from the purchase of stationery, advertizing, printing water loan certificates, making out water tax books, drawing mortgages, contracts, etc. These amount to one thousand seven hundred and ninety-six dollars and seventy-six cents.

The total amount of expenses incurred on account of the Water Works is two hundred and twenty thousand, three hundred and ten dollars and fifty-five and an half cents.*

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* The original estimate of the Engineer for the entire completion of the works is one hundred and twenty-seven thousand dollars, including one hundred and four thousand feet of pipe, of which twenty-nine thousand nine hundred and sixty three have been laid.

Respecting the period when the works may be completed, the Committee need only observe, that whenever Councils shall give directions, and provide adequate means, the whole may be finished in a very short time.

By order of the Committee for Supplying the City with Wholesome Water,

JOHN MILLER, JUNR., *Chairman.*

THE ALBO-CARBON LIGHT.

BUSINESS MEETING, NOVEMBER 7TH, 1885.—Mr. F. H. Bowen, Jr., presented the following:

The Albo-Carbon Light, an English invention, in use in England and on the Continent about four or five years, and lately in this country, is merely a light made by the consumption of coal, natural, oil, or water gas, gasoline, etc., enriched with carbon.

The means of attaining this end are very simple.

The carbon is obtained from volatile hydrocarbons, such as naphthaline, heavy oils, etc., which are slowly vaporized in a suitable chamber, the vapor mixing with the gas immediately before consumption. Attempts have been made to place the carburetting material some distance from the burner, but these have failed, owing to the clogging of the pipes by the condensation of the vapor, a temperature of at least 170° Fahr. being necessary to maintain a vaporous state.

With the present form of light the carbon is supplied by a substance known commercially as Albo-Carbon, a pure, white, refined form of naphthaline, extracted from the dead oil of tar, and cast into sticks about the size of candles. At present this is manufactured only in England.

The enriching apparatus consists of a chamber containing the albo-carbon, and provided with a suitable arrangement of pipes by which the gas is made to circulate among the pieces of albo-carbon and then led to the burner. The albo-carbon in the large or cluster-lights is vaporized by the gas itself, which has been previously heated by circulating through a hollow disk situated immediately above the flame. This previous heating of the gas also increases its illuminating power. In the small fixtures there is, over the flame, a piece of metal fastened directly to the carburetting chamber, which, by its conductivity, heats the chamber, and thus vaporizes the albo-carbon. The tubing is provided with a three-way cock, by which, should the supply of carbon be so great as to cause smoking, the gas may be led directly to the burner, or part of the gas so led, and part led through the albo-carbon, thus lowering the amount of enrichment.

The containing chamber never needs cleaning, the volatilization always being perfect.

Experiments showed that five feet of gas burned per hour, with a standard argand burner, at a pressure of $\frac{7}{10}''$ equaled 17.20 candles, and that the same amount of carburetted gas equaled 40.625 candles, or 2.36 times the power of the standard argand. This was with the small generator, where the carbon is heated directly. With the largest cluster-lights, 48 burners, where a higher temperature of gas is obtained, 11 candles to one foot of ordinary 16-candle-power gas results.

After careful investigation and exhaustive competitive trials, this light has been adopted in the cars of the Chemin de Fer du Nord, in France, and is now in successful use.

Prominent among the many large buildings, railroad stations, etc., lighted by this system that might be mentioned as examples, are: The Victoria Station of the London

and Brighton R.R., the Grand Depot, St. Pancras, London, and all other stations of the Midland Railway Company, and the stations of the Buenos Ayres Railway.

The advantages claimed for this light are: simplicity and cheapness of plant, the fixtures may be connected without any alteration of existing mains, meters, piping or general arrangement; economy, assuming the cost of gas at $1.60 per thousand cubic feet, the present Philadelphia rate, and adding 40 cents, the cost of the carbon—about four pounds being consumed with each one thousand feet of gas burned—we would have for $2.00 an illumination that exceeds that from 3,000 feet, as per experiment, burnt in the ordinary manner, at a cost of $4.80; a gain of $2.80 per thousand feet; a brilliant, white and steady light; safety, the albo-carbon being non-explosive; sanitary, the amount of gas consumed and heat generated in combustion of albo-carbon gas is, light for light, much less than in use of ordinary burner, the air, consequently, being vitiated to a much less degree.

THE NEW CROTON AQUEDUCT.

Regular Meeting, November 21st, 1885.—The Secretary presented, for Mr. W. S. Church, a large number of photographs, tracing, pamphlets and other documents, illustrating the design and progress of the New Croton Aqueduct, and read two communications from Mr. Church. He says: "The '*ground*' through which the tunnel is advancing, is largely gneiss with considerable limestone, felspar, and occasional quartz seams. The dips are so vertical that much roof rock comes away. This trouble is increased by the too free use of high explosives near the perimeter of the vertical section, so that the area excavated runs from 25 to 50 per cent. in excess."

"A most careful system of measuring and recording just what is excavated is being carried out. A vertical dial, which the boys call 'The Sun Flower,' is set up every 10 ft., and oftener if necessary, and radial measurements taken to all the inequalities of the section; these measures are plotted on the diagrams, and the areas estimated with the planimeter."

"The principal difficulty that the line has yet encountered, is the Gould Swamp. It has finally been decided to under run this in solid rock with an inverted syphon, making a blow-off below grade and draining by an adit out into the Hudson River."

In Vol. V, No. 1, page 13, in a discussion of Mr. A. Harvey Tyson's paper on Pollution in Storage Reservoirs, I notice that Mr. Charles G. Darrach says, 'I would call attention to the fact that in the proposed Quaker Bridge Dam for the New Croton Aqueduct, no provision seems to have been made, as far as can be learned from published plans, for draining off the water from the lower levels. As this dam will be of almost unprecedented depth, the same trouble may be expected as in Baltimore and Reading, unless this precaution is taken.' "The Club will observe from the drawing sent, that this criticism is fully met, and that the big reservoir of the Croton will, when constructed according to present designs, have the best *circulation* of any reservoir in the world."

A MOVABLE DAM.

Regular Meeting, November 21st, 1885.—Mr. Wm. H. Dechant presented the following:

The movable dam, built by the United States Government at Davis' Island, below Pittsburg, in the Ohio River, described by Prof. Lewis M. Haupt, in his paper read to the Club in December last, is, no doubt, the best large dam in practical use in this country to date.

The purpose and object of movable dams is so well shown in Prof. Haupt's paper, that any additions here are unnecessary, suffice it to say, briefly as a matter of introduction. The rendering of the Ohio, and many other rivers, navigable during the dry season, making of them highways which shall be uninterrupted by the low water stage of summer, is, without question, the important mission of the movable dam. The Ohio River, as a representative, fluctuates 60 feet, or more, between low water of summer and high water of freshets. By movable dams the flow of the minimum stage may be so utilized as to supply the necessary depth for navigation. This depth could be secured by permanent dams, but such dams also stand as a permanent obstruction, and shipping would be compelled to pass with much delay through a lock at each dam, no matter whether the water in the river were at a flush or low stage.

The system of movable dams embraces all the advantages in river or slack water navigation. When the water in the river is flush, the dam is down, and lays below the bed of the stream, and offers no more obstruction to the passage of boats than no dam at all.

When the water subsides to a medium stage, a part of the dam or weir is raised, and the flow of water down the river is retarded, and made to pass through only a part of the dam left open, enabling shipping to pass through without causing a delay to pass them through the lock. When the river subsides to its minimum stage, the whole dam is raised, and the flow of the water down the river is almost entirely retarded, and all shipping passes through the lock, thus husbanding all the water in the stream, and holding it to the proper depth to float the craft, until the river rises again by rains sufficiently to allow of a navigable pass to be opened in the dam, to allow boats to pass through and discard the slow process of lockage.

In this country the movable dam is in its infancy, and seems, as yet, to be under the shadow and fostering care of its grandparents from across the water, but a steady diet of American water will soon rear it into American manhood.

The subject is of growing importance; the utilization of the waste waters and waste powers of our rivers can only be secured by dams best suited to the various purposes and needs, and as there are millions in it, we can safely trust the development to American capital and the American engineer, or rather *vice versa*.

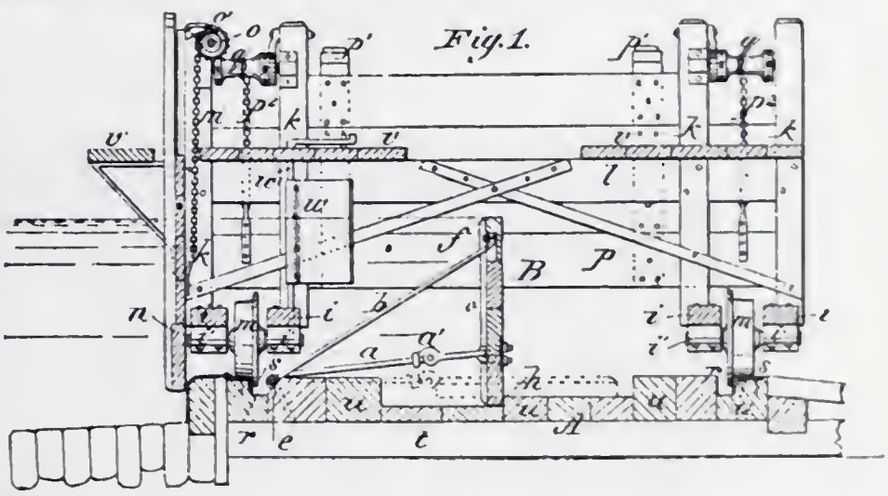
The system of wicket to which I wish to call your attention, has been practically tested on a small scale, in the shape of supplemental strips, or flush strips, on permanent dams on the Schuylkill navigation of the Philadelphia and Reading Railroad Company. The first were placed on Pawling's Dam, below Perkiomen Junction, during the Summer of 1881, and have been giving very satisfactory results, without requiring any repairs worthy of note thus far. The strips have also been in use on Kernsville Dam, above Hamburg, Pa., since the Summer of 1882, and at the cut-off dam at Schuylkill Haven. The combs of Black Rock Dam, above Phœnixville, the dam below Landingville, and a part of the comb of Norristown Dam have been built with a view to using them. The strips in use at the above-named places are from 12 to 20 inches high, and a strip or wicket 10 feet long, made of two-inch oak plank well

bolted together, is easily manipulated by one man walking out along the comb of the dam. Formerly, the placing of loose plank back of upright pins fixed in the comb, was a work accomplished with difficulty under the same conditions by two or three men, and such loose strips were frequently carried off by freshets, and the pins either bent or broke, thereby damaging the comb timbers.

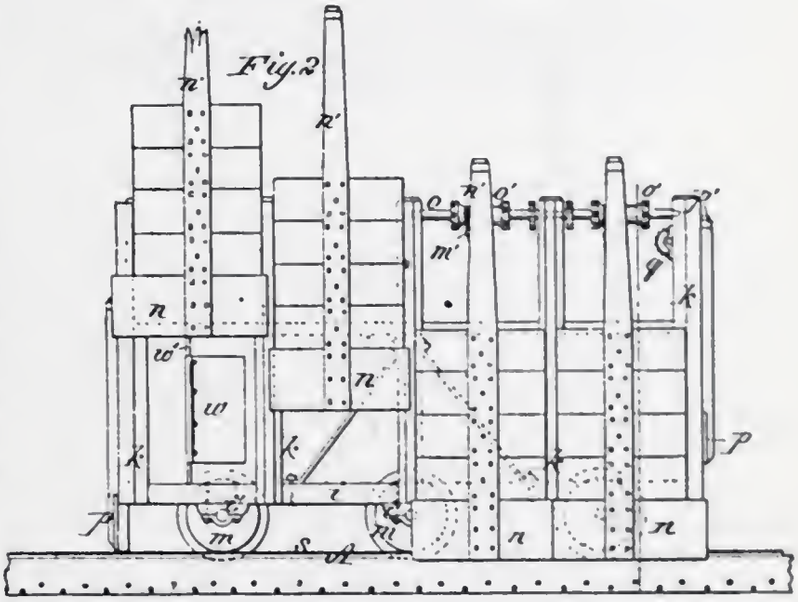
One of the great advantages in this system of wicket is that the force of the water itself assists in raising the wicket. I might here state the object or purpose of supplemental strips, or wickets, on top of permanent dams:

On almost all permanent dams, whether used for navigation, water power, or water supply, it is found advantageous and necessary during the low stage of water, to erect temporary strips, or flush planks, on the comb, so as to save the water from wasting over the dam, and also for maintaining a proper depth in the dam. It will readily be understood how important such strips are, when, by simply raising them on the top of the comb, say 12 inches in height, they pond a cubic foot of water, or $7\frac{1}{2}$ gallons, for every square foot of surface of the dam, which is often miles in extent.

I will here, by the aid of a few plates, endeavor to explain and describe the construction and operation of the system.



The plates show a timber construction. Iron would be better for the caisson, because it could be built to offer less resistance to the current of the water. The plan for foundation will have to be changed to suit the numerous different conditions of the bottom of the stream, the same as for permanent dams. *Figure* 1 shows an end section of the foundation *A*, the wicket *B* in an upright position, and an end section of the caisson operating truck, covering the foundation and wicket. *Figure* 2 shows the up stream side of the caisson operating truck, with the gates *n* working vertically, to enclose a wicket, when necessary to make repairs; the gates are forced down by striking on the handle p' and are raised by a chain p^2, wound around a horizontal roller *o*,



operated by capstan bars.

Figures 3 and 4 show an end section of the foundation *A*, with the wicket *B* in an upright position, or up, the same as in *Figure* 1, and in a horizontal position, or down, without showing the caisson operating truck. *Figure* 5 shows the up stream face of the wicket *B*, when in an upright position. *Figure* 6 shows the top view in the same position, and *Figure* 7 the end view. These figures show the simple fastenings of the hinges *a*, the holding bars *b*, the batten plank or timbers *c*, the sluice opening and sluice gate *d*, and the revolving bars *f*. *Figures* 8 and 9 show the wicket *B* in the simple form for flush strips on top of permanent dams, *Figure* 8 showing the wicket up, and *Figure* 9 showing it down.

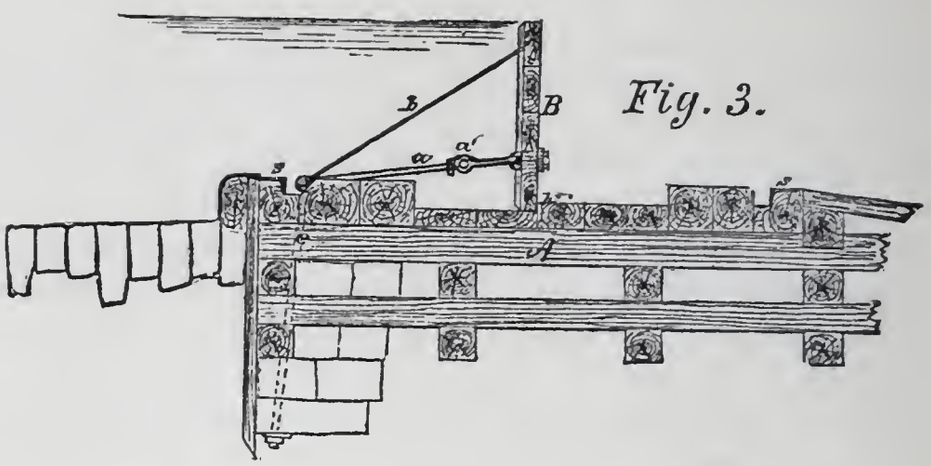


Fig. 3.

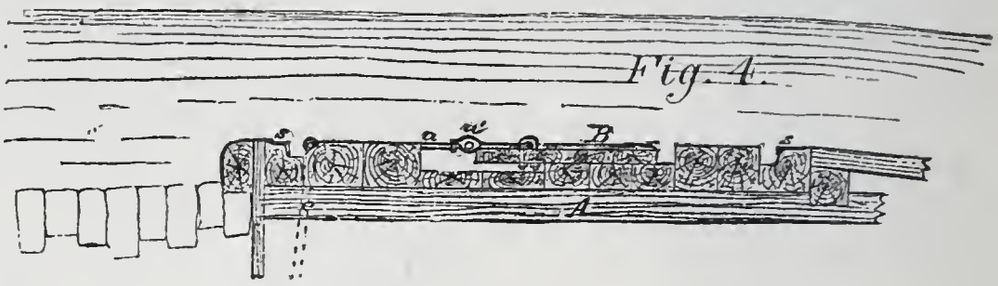


Fig. 4.

Fig. 5.

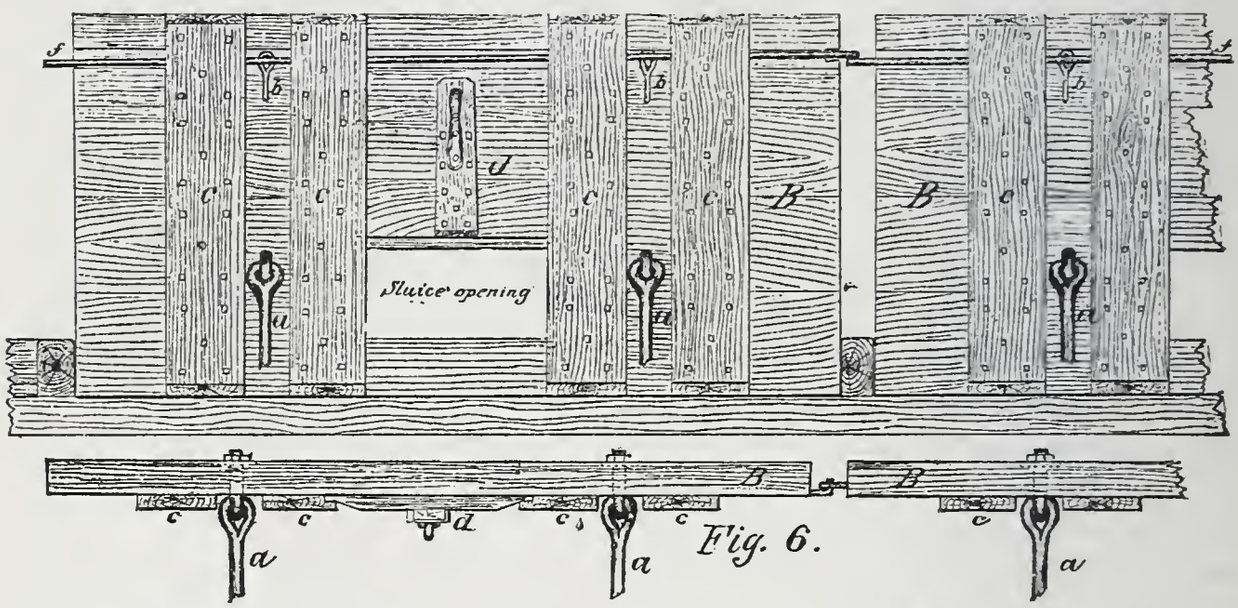
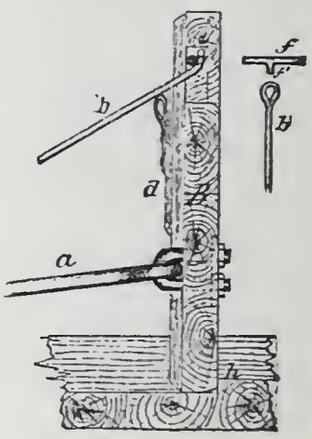


Fig. 6.

Fig. 7



A glance at the plates will at once show the simplicity of the construction of the wickets, hinges, etc.

It will be noticed, the wickets are supported by a tension hinge *a*, instead of by a prop, as used in the Chanoine system; a tension hinge can be made much lighter than a prop to have the same strength. The hinges *b* are attached at one-third the height of the wicket, which point is the centre of pressure; the

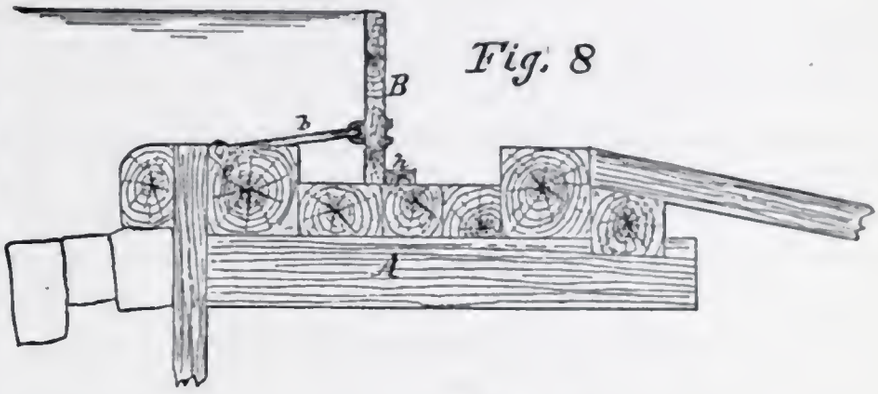


Fig. 8

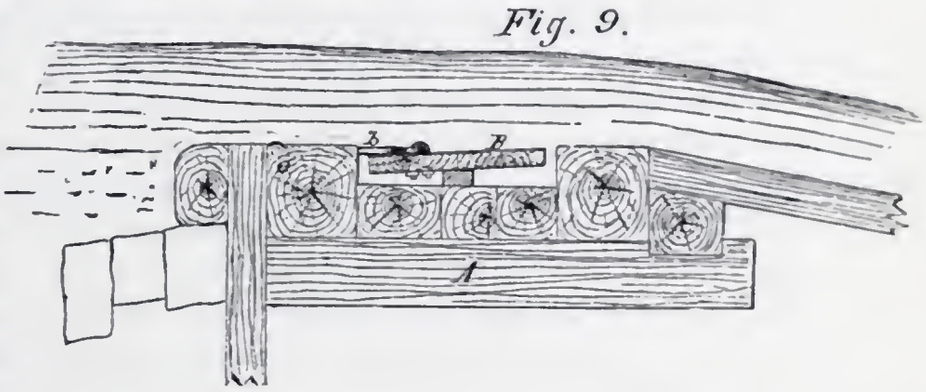


Fig. 9.

holding bars *b*, coupled to the revolving bar *f*, secure the wicket in an upright position against any accident or cause, by which it might lose its balance, until they are released by the attendant, and allow the wicket to fall. The hinges *b* can be made amply strong, to withstand any strain to which they may be subjected; they have a knuckle-joint a^1, to allow them to bend, in case any obstruction should get under them when the wicket is lowered. In lowering the wickets, it is necessary that the holding bars *b* should all be released at one and the same time; to accomplish this they are all coupled or hooked to the one revolving bar *f*. This bar is held from revolving by a right angle bend at one end, resting in a notch in the end of the wicket. When it is desired to throw the wicket down, all that is necessary is to move the bar endwise, by striking it until it is free of the notch, when it will revolve and drop the holding bars, thus releasing the wicket and allowing it to drop. If it is at any time desired to arrange the dam to drop all the wickets across the stream, without making it necessary for the attendant to go to each wicket separately, and release the revolving bar, the revolving bar on each wicket is simply moved endwise enough, so that instead of their bent ends remain resting in the notch of the wicket, they shall rest on the end of the revolving bar next to them, so that when the first wicket at the shore is dropped, it will release the revolving bar of the wicket next to it, and so on all the way across the dam. The wickets generally should be arranged to stand independent of each other, so that if any accident happens to one, it would not affect the others. It will be noticed by a glance at *Figures* 8 and 9, that as soon as the wicket is partially raised, the pressure of the water on the lower part of the wicket below the hinge will assist in raising the wicket; this is found to be practically the case, and the same principle applies to wickets of any size. This fact, together with the positive position of the attendants immediately over the wickets, and the practicability and advantage of using steam power on the operating truck, will enable the dam to be manœuvered rapidly.

A great advantage in this system with such appliances, is the practicability of making the wickets much wider or longer lengthwise of the dam, thereby lessening the number of wickets and making the manipulation of the dam more rapid, and also making the wickets themselves more stable, solid and compact, and reduce the number of spaces between the wickets, thereby preventing much leakage when the dam

should be tight. The sluice-openings in the wickets will afford additional means to regulate the surface of the water in the dams.

It will be noticed in *Figures* 8 and 9 there are no holding rods or wires to keep the wickets in an upright position, and it is found if the wickets are low and can be manipulated by a man walking out along the comb of the dam, such fastenings are unnecessary, if the hinges are fixed at the $\frac{1}{3}$ point, the friction of the wicket on the bottom will keep them from falling. If the wickets are higher than one foot above the dam, and it is desirable to have stays to hold them in position until released from the shore, the hinges should be attached a little below the $\frac{1}{3}$ point, so that they would be thrown promptly by the water when the stays are released. For low flush strips it would hardly be necessary to use the revolving bars for releasing the stays, as is done in the movable dam wickets: light wires or pieces of lath can be used to support the wickets from falling when the water is at its usual stage, in such a manner as to be torn down by the force of floods, or a light chain can be paid out across the dam back of the wickets, through the links of which the small wires holding the wickets can pass and be torn down by the reeling up of the chain on the abutment.

I claim the following advantages for the system:

1. Simplicity of construction, a small number of parts and but few wearing parts, the practicability of making the wickets wider lengthwise of the dam; securing a more stable, compact and substantial structure.

2. The principal movement of the wicket is simple and complete; when it falls or is knocked down by accident, it falls completely and clears the channel, and there are no props or hinges to be damaged, because the wicket in turn supports the tension hinges, and both fall together.

3. The principle of the wicket is such that the pressure of the water itself assists to raise it.

4. When the wicket falls there is no danger of damage from the jar, because it falls with its flat face into a cushion of water, and there is no ponderous iron work below it to be damaged, or to cause damage.

5. The wickets can be thrown either separately or collectively across the pass and weirs, as may be most desirable; they can be left standing, independent of each other, until it is desired to throw them, when the revolving bars can be first adjusted all the way across the dam, so as to depend upon the wickets next them, and the whole dam lowered by releasing the one wicket next to the abutment, which, in falling, will release the next one to it, and so on consecutively all the way across the dam.

6. The tension hinges, when the wicket is down, lap over the breach of the wicket, and no current of water or floating body can get under the wickets to raise them above the recess in which they lie.

7. The sluice openings in the wickets provide an additional means to regulate the surface of the water in the dams, as the water is vented through them under pressure of the head above them.

8. The manipulating of the dam is done from a caisson operating truck, passing directly over the wickets, and enables the attendants to make careful examinations, and be in a position to remedy any defect, and also provides a means of enclosing a wicket or a number of them completely, to make any needed repairs, and if desired, can be made to enclose all sides, and enable the water of the height of the lower dam to be pumped out, and allow repairs to be made in the dry.

9. A sudden flood, of which the movable service bridge stands in continual danger, will not affect the caisson operating truck in its shelter at the abutment.

10. The caisson operating truck is not at the mercy of the water as manœuvering boats are, but can be ballasted to stand firm in any current likely to be encountered during the time its use is required.

11. The form of the caisson operating truck is such that it can be enlarged to any size desired, and be able to carry its own motive force and power to manipulate the wickets, and do pumping if desired.

12. Stronger and more compact form of the top of the foundation, and the shelter of the important face of the sill, under the wicket, when it is down, so that it is not subject to abrasion and damage, as is the sill in the Chanoine system.

I claim the following advantages for the use of the wickets as flush strips on the combs of permanent dams:

1. The saving in time, labor and material, in having strips unharmed by floods.

2. Having the strips always on the dam ready to be raised whenever required, without the delay of gathering materials.

3. The comb of the dam is not damaged by them, as it is by the use of iron pins, but it is rather increased in strength by the additional width at top necessary to receive the recess in which the strips lay.

4. They act automatically in times of ice freshets, and after they are down do not obstruct the flow, and offer no hold for rubbish and debris, as do iron pins.

5. When the water is low no up-stream wind can blow them down, as is sometimes the case with loose flush plank.

FASTENINGS FOR BRIDGE FLOOR TIMBERS.

Regular Meeting, November 21st, 1885.—Mr. A. R. Roberts exhibited an appliance for Fastening the Floor Timbers of Highway Bridges to the iron I beams of the floor system. It consists of a piece of flat wrought iron cut from the ends towards the middle, the divided portions being bent at right angles to the piece so that one opposite pair, after being ragged, can be driven in the wood, and the other pair bent under the flange of the iron beam.

MITIS METAL.

Regular Meeting, November 21st, 1885.—Mr. P. Oestburg, introduced by Mr. Henry G. Morris, presented the following:

As it is but a couple of hours since my invitation to address this association, I am in the happy position of not feeling under any obligation to apologize for not delivering an eloquent speech, or reading an elaborate paper. I am merely requested to tell something about the new product named "Mitis Castings," and I shall try to do so as briefly as possible.

I will first draw your attention to the fact, that the manufacture of castings cannot be looked upon as one proceeding; it consists of several quite separate operations: the preparing of the mould, the melting of the metal, the making of the metal suitable for the purpose, and the pouring of the metal into the mould; each of which operations must be satisfactory for attaining a successful result. When we come to the question of making castings from metals so difficult of fusion as wrought iron, no ordinary means

for either of the above-named operations is sufficient for producing such results as these samples you see before you. It is only through very essential improvements in *every one* of the different operations, we have attained success.

I claim that no moulding sand, formerly known, has been fireproof enough for pouring wrought iron into. If a sand is not fireproof enough, it fuses and sticks to the casting, thereby producing a rough surface. My moulding material consists only of very good fire clay, very hard burnt, finely pulverized, and the smallest possible quantity of binding material. Others have added burnt fire clay to moulding sand for improving it. The essential thing in my moulding material is to avoid mixtures, and to use the hard burnt fire clay *alone.* As a binder, I prefer sugar or molasses, as these materials neither make the moulding material fusible, nor make the castings hard, nor give away any gases. From the samples, which you can satisfy yourselves are from the softest wrought iron, you can see that the sand is excellent.

As regards the melting of the metal, I do not claim that my mode of melting is the only one for attaining sufficient heat. But I claim that the system under my control is at present the only one which accomplishes the result in a sufficiently convenient way to secure practicability. I use petroleum, which is burned with the admission of atmospheric air. As yet I use in this country only a crucible furnace. I melt the wrought iron in from 70 to 50 minutes, making 11 to 12 meltings in a day of 12 hours, the crucible each time being quite filled, whereas in other methods of melting in crucibles only three meltings are accomplished in 12 to 16 hours with decreasing charges.

When the metal is molten, I prepare it for pouring in a way the details of which it would take too long to explain to your satisfaction. It is sufficient to say that I have a means of making the metal extremely fluid, so that it will let all gases that may be present pass away, and will run freely into the finest moulds, as you see by the samples.

I have further mechanical appliances by which I can keep the metal in a proper state for pouring for a considerable time. I use a covered casting ladle, within which I produce a very hot flame, which has its outlet over the pouring lip. By this apparatus I can keep wrought iron in a proper state for pouring as long as twenty minutes, and even longer.

What I accomplish is to melt wrought iron and pour it into castings, which retain all the qualities of the raw material, are practically solid, and have a beautiful surface.

An incidental quality of the castings is that the tensile strength is from 20 to 50 per cent. greater than for the raw material. I ascribe this solely to the sudden contraction in the cooling from the melting point of wrought iron, not to any intrinsic quality of the metal.

COMPRESSED FUEL.

Business Meeting, December 5th, 1885.—Mr. Washington Jones presented to the Club, through Mr. John T. Boyd, some specimens of Artificial Fuel made in Belgium, and sent to him from there by Mr. E. F. Loiseau, who is now abroad experimenting on its manufacture.

The specimens are on exhibition at the House of the Club, and consist of cylinders having a hole along their axes, cubes, perforated square blocks, and two sizes of egg-shaped masses, corresponding about to our "egg" and "stove" sizes of anthracite coal.

This fuel is made of bituminous coal dust, coal tar pitch and clay, mixed in suitable proportions and compressed into the shapes named.

Some few years ago, Mr. Loiseau was making the smaller of the egg-shaped sizes in this city, and then the material was passed through rollers having recesses which formed the eggs.

A peculiarity of these eggs was that they retained their shape until all the combustible material was entirely consumed, and then fell apart in a fine powder. The specimens shown bore labels stating the quantities of the several sizes made per day.

THE FORTH AND TAY BRIDGES.

Regular Meeting, December 19th, 1885.—Mr. Thomas C. Clarke, through Mr. Thomas M. Cleemann, presented an account of the impressions gained by him last summer during a visit to the Forth and Tay Bridges. He added to a description that he had already given to the Scientific American Supplement, sketches showing the positions of the erecting scaffolds for the first named structure, and the method of building the piers of the second of plate iron filled with beton and loaded with pig iron to twice the greatest load that they will ever have to support, before the weight of the superstructure is imposed upon them. The floor of the latter bridge is made of steel plates compressed into a corrugated form, each three-eighths-inch plate forming one corrugation eighteen inches wide and ten inches deep, rivetted at the edge to the adjoining overlapping plate, and reaching from girder to girder, about sixteen feet between bearings. On the through spans, where the bearings are twenty-six feet apart, half-inch thick channels and plates are rivetted together, so as to make a series of trough-like corrugations, eighteen inches wide at the top and twelve inches at the bottom, by eighteen inches high, on which longitudinal stringers of wood are laid, to which the rails are bolted. This floor system is intended to be strong enough to carry derailed trains and take the place of cross floor beams, track stringers and horizontal wind bracing. The weight per foot does not exceed that of our floor beams, etc., but it requires the lower chords of through bridges to be made stiff like those of swing bridges, instead of using eye bars.

At both bridges great ingenuity in inventing and applying new methods was displayed. A very interesting tool is the twin hydraulic rivetter, with two rams pressing each head simultaneously, the lower one having an area one-half inch greater than the other, and, being first brought to bear against the finished head, the upper one completes the rivet.

For the erection of the towers, a scaffold consisting of a pair of lattice girders rivetted together, will be raised, by hydraulic power, up along the main columns by means of slots and pin holes in the columns and movable pins. This scaffolding will afterwards form a portion of the permanent structure. After the completion of the tower, similar lattice girders will be suspended on each side by temporary suspension cables, to be used for placing the pieces finally in position.

A NOVEL RUBBER AND STEEL SPRING.

Regular Meeting, January 16th, 1886.—Mr. Howard Constable presented the following:

This spring is the invention of an American Engineer, Mr. L. Sterne, proprietor of

the Crown Iron Works of London and Glasgow. The model represents the usual form adopted when the spring is used for draw bars, buffers and the like; the form of the rubber and the cross section of the steel spring can be altered to suit various conditions, either where a uniform resistance is required throughout the whole range of compression, or where a gradually increasing resistance is required. I also perceive that where it is desirable to have a spring which is easy and yielding throughout part of its range, and then arrests further motion but not too abruptly, the steel spring can be fitted and made so as to check the rubber just at the right point, and without the shock which occurs when the solid stops or bearings of springs come together.

As you see, the rubber part of the spring is of an ordinary pine-apple shape, or more accurately, two parabolic truncated cones, base to base, and encircled by a flat steel ring. This ring is not solid; the ends overlap each other for a distance about one-quarter of the circumference, and slide over each other as the ring is spread apart by the rubber when it is compressed.

The ring is made of flat rolled steel, or, if necessary, with a cross-section of a flattened U or W form, in order to give greater resisting power. A mould or fillet around the middle of the rubber fits into the channel of the rings with U or W cross-sections, and keeps them from working out of position. The flexure or bending backwards and forwards of the steel caused by the opening and shutting of the ring, when the rubber is compressed and relaxed, is so little compared to the total length of the ring, that the strain brought upon the fibres of the steel is very far within the elastic limit of the steel, so that the life of the ring is almost unlimited. Some springs that have been undergoing test at the shops of the Northeastern Railway of England, have "withstood," up to January, 1886, "over one million compressions of five tons, and have not lost in resistance, range or weight, and have surpassed every other spring in competition," I have recently been informed. The rubber bulges outward as it is compressed and spreads the ring apart, which all the time resists and tries to keep the rubber in its original position, and the more the rubber is compressed and distorted, the greater become the force of the ring and the amount of work done by it.

So the rubber is always reinforced and supported by the steel spring about it, the more it requires it and the nearer the point of collapse is reached.

Up to the present time quite a number of these springs have been manufactured, principally for use in draw-bars and buffers of railroad cars, but no doubt the idea can be applied to many other cases, since, while retaining all the good features of a rubber spring, it requires less rubber and adds some qualities in the direction of resistance and endurance which make it a very close approach to a perfect spring, and presents valuable features of economy. In the case of street cars the duty of a spring is very severe, and the spring experiences an immense variation in load, yet it should be uniformly elastic. An empty car may weigh one ton, and when crowded it will weigh five tons; and this variation of load may come gradually or all at once, and always in jerks, owing to the getting on and off of the passengers and the swaying of the car, caused by the unevenness of the track; thus the question of what spring gives the highest endurance and best proportioned resistance to the duty imposed, is an important consideration.

CHANGES IN LIST OF MEMBERS.

ACTIVE.

Additions, November 7th, 1885.

King, Jos. B., Foreman of Machine Shop, Midvale Steel Co., Nicetown, Phila.

Campbell, John W., Asst. Supervisor P. R. R., Blairsville, Pa.

Craighill, Wm. P., Lieut. Col. of Engrs., U. S. A., 378 St. Paul St., Baltimore, Md.

Bridgers, Jr., R. R., Supervisor P. R. R., Trenton, N. J.

Datesman, George G. E., Asst. Engr. Phila. Survey Dept., City Hall, Phila.

Cox, Allan, Civil Engr., K. C. R. R., Covington, Ky.

Tripler, Henry E., Asst. Engr. R. & P. R. R., Merchants Hotel, Pottsville, Pa.

Covode, J. H., Asst. Supervisor P. R. R., 28th St., Pittsburgh, Pa.

Wilson, John, Engineer Phila. Traction Co., 23d and Brown Sts., Phila.

Salom, Pedro G., Metallurgist and Chemist, 208 S. 4th St., Phila.

Low, Theo., Asst. Engr. P. S. V. R. R., Pottsville, Schuylkill Co., Pa.

Rohrer, Jacob B., Div. Engr. P. & M. R. R., Saint Clair, Schuylkill Co., Pa.

Low, Emile, Asst. Engr. P. & M. R. R., Hazelton, Luzerne Co., Pa.

Prevost, Sutherland M., Genl. Supt. Transportation, P. R. R., 233 S. 4th St., Phila.

Churchill, Chas. S., Prin. Asst. Engr. P. & M. R. R., Pottsville, Pa.

Additions, December 5th, 1885.

Wingate, E. B., Chief Engr. K. C. & S. W. R. R., Arkansas City, Kansas.

Zacharias, Henry C., Asst. Min. Engr. P. & R. C. & I. Co., Shamokin, Pa.

Laureau, Louis G., Mech. Engr., Gordon, Strobel & Laureau, 226 Walnut St., Phila.

Gordon, Fred. W., Mech. Engr., Gordon, Strobel & Laureau, 226 Walnut St., Phila.

Patton, W. M., Engr. in Charge Schuylkill River Bridge, B. & O. R. R., Gray's Ferry, Phila.

Strobel, Victor O., Mech. Engr., Gordon, Strobel & Laureau, 226 Walnut St., Phila.

Morris, A. Saunders, Mech. Engr., 209 S. 3d St., Phila.

Broomell, A. P., Mech. Engr., Supt. Engine Dept., Penna. Agricultural Works, York, Pa.

Wood, Howard, Manager Alan Wood & Co., Conshohocken, Pa.

Mencke, Wm. F., Mech. Engr. Southwark Foundry and Machine Co., 430 Washington Ave., Phila.

Lukens, Lewis N., Mech. Engr., Alan Wood & Co., Conshohocken, Pa.

Additions, January 9th, 1886.

Smith, Albanus L., Asst. Engr. Manly & Cooper Manufacturing Co., No. 6 East Penn St., Germantown, Phila.

Williams, Samuel T., Mech. Engr., Gen'l Mgr. Steel Department Henry Disston & Sons, Tacony, Phila.

Pettit, Robert E., Gen'l Supt. Pa. R. R. Co., Altoona, Pa.

Cornelius, H. R., Mech. Engr., Southwark Foundry and Machine Co., 430 Washington Ave., Phila.

Resignations.

Austin, T. Everett,
Babcock, W. Irving,
Beatty, James, Jr.,
Hexamer, C. John,
Leuffer, Andrew B.,
Norris, Thaddeus,
Winslow, Arthur,
Winston, L. M.

Deceased.

Pierce, Dwight Edward, September 1st, 1885.
Bergner, Theodore, January 5th, 1886.

ASSOCIATE.

Additions, December 5th, 1885.

Esherick, Frank K., Iron and Steel, 263 S. 4th St., Phila.

Gordon, L. Frank, with Gordon, Strobel & Laureau, Engineers, 226 Walnut St., Phila.

Statement of Membership to February 1st, inclusive, 1886.

Honorary, 3; Corresponding, 5; Active, 418; Associate, 8.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

Vol. V.] APRIL, 1886. [No. 4.

XXI.

HARBOR STUDIES.

Being a consideration of the physical phenomena attending the formation of bars at the entrance to harbors in alluvial formations, with some proposed remedies.

By Prof. L. M. HAUPT, Active Member of the Club.

Read January 16th, 1886.

NEED OF DEEPER WATER.

SINCE the amount of capital invested in the coast-wise trade of the United States is far in excess of that invested in the commerce of any country on the globe, it is of great moment that the risks to the property and lives so employed should be reduced to the lowest practicable limit. As a means to this end, aside from a proper illumination of the coast and marking of channels and obstructions, there should be provided frequent and capacious harbors of refuge for shelter from storms.

An inspection of the Atlantic coast-line, from New York to Mexico, shows a stretch of about 3000 miles, deeply indented with bays, inlets, rivers and sounds, which would appear to furnish frequent retreats for shelter, but a careful examination of the "bottoms" at these inlets will generally reveal a submerged obstruction, which makes it dangerous for vessels to approach them in time of greatest need; in consequence whereof, our coast-line is frequently strewn with wrecks, an extensive system of life-saving stations must be maintained, and millions of money must be expended to afford an entrance to a roadstead even at a few distant points.

List of Principal Harbors and Inlets, from New York to Cedar Keys.

Name of Inlet.	*Latitude Crest of Bar.*	*Depth on Crest of Bar—Mean Low Water.*	*Dist. from Crest to nearest point of Coast.*	*Average Rise of Tide.*	Remarks.
			Miles	Feet.	
New York Harbor	40°43′	23 ft.	8	4.8	
Barnegat Inlet	39°46′	7 "	½		
New Inlet	39°27′	9 "	1½		Mullica River Great Bay.
Absecon Inlet	39°22′	7 "	¾	4.3	1880.
Delaware B. W. Harbor	No bar at entrance.			4.3	Artificial.
Chincoteague Inlet	37°53′	8 ft.	1 mile		
Great Machipongo Inlet	37°22′	13 "	1½"		
Sand Shoal Inlet	37°16′	16 "	2 "		Connects with Magothy Bay.
Ship Shoal Inlet	37°13′	8 "	1 "		
Norfolk Harbor	36°55′	21 "	3 "	2.5	
Cuffy Inlet	36°13′	0 "			Closed.
Old Inlet at Nag's Head	35°56′	0 "			Now a Sand Dune.
New Inlet	35°41′	Less than 6			
Loggerhead Inlet	35°34′	0 ft.			Closed.
Hatteras Inlet	35°12′	14 " 10 "	1 " 2½"	2.0	Outer Bar } Subject to frequent changes Inner " } & buoys shifted accordingly.
Ocracoke Inlet	35°05′	12½ 7 ft.	1¼" 3 "		Outside in 1883. Inside.
Beaufort, N. C.	34°40′	15 "	1½"	2.8	
Cape Fear, N. C.	33°50′	14 "	1 "	4.4	
Charleston Harbor	32°43′	12½"	3 "	5.1	In 1871.
N. Edisto Inlet	32°33′	11 "	3½"	5.8	
S. " "	32°27′	13 "	5½"		Protected by breakers, shoal.
St. Helena Sd.	32°24′	12 "			In east channel.
	32°20′	16 "	6 "	5.9	In main and south channels. Coosaw R. and
Port Royal Inlet	32°08′	21 "	7½"	7.0	Broad R. are connected 22 miles from coast.
Tybee Roads	32°00	20 "	5 "	7.0	
Wassaw Sd.	31°54′	14 "	4 "		
Ossabaw Sd.	31°49′	12 "	1 "		
St. Catharine Sd.		11 "	5 "		
Doboy Sd.	31°22′	14 "	5 "	6.6	
Altamaha Sd.	31°18′	11 "	4 "		
St. Simon's Sd.	31°05′	14 "	6 "	6.8	
St. Andrew's Sd.	30°57′	15 "	6 "		
Cumberland Sd.	30°42′	11 "	2 "		At mouth of St. Mary's River, in 1874.
Nassau Sd.	30°29′	7 "	½ "		
St. John's River	30°23′	8½"	¾ "	4.5	
St. Augustine	29°54′	9 "	1 "	4.2	
Galveston	29°21′	13 "	4¾"	1.1	S. Jetty built 1874–1885.

40 L.S. Stas.

11 L.S. Stas.

21 L.S. Stas. 5¼ miles apart.

From this table it appears that in these 1400 miles of coast there are but four natural harbors where the depth at mean low water exceeds 16 feet, and they are New York, Norfolk, Port Royal, S. C., and Tybee Roads, at the mouth of the Savannah River, where the depths are 23, 21, 21 and 20 feet respectively, while the largest ocean vessels draw from 26 to 28½ feet of water when fully laden. At New York therefore, and at an average high tide, there would be danger of striking bottom even in still water. Some of these inlets are not available for harbors, having no anchorage inside, and in some others there is an inner bar, where

the depths are less than on the outer. At the important entrances of Charleston and Galveston there are but about 12 feet. It should also be observed that, where the depth is greatest on the crest of the bar, its distance from shore is greatest, and these quantities will be found to vary with the volume, direction and velocity of the discharge. In places where there is an inner bay of considerable extent, there will also be found an inner bar produced by the flood tides; and in general, the plan of the water courses on the inside of the entrance will be found to consist of three distinct features, due to the spreading out of the flood tide and the restriction of flow of the fresh water discharge. Where the coast is low, these waters form the sounds, bays and lagoons, which extend nearly parallel to the shore and form the tidal reservoirs, which may be appropriately styled the *tuyeres* of the inlet, or the lungs of the ocean.

The condition of the channel will be found to depend very largely upon the relative direction of the axes of discharge from these reservoirs and the land drainage, as well as upon the slopes. Thus if the axes are separated by 90° each, there will be an opposition of the currents from the lateral channels in the face of the fresh water discharge, which will greatly diminish its energy and scouring capacity. As the angle diminishes, or the currents approach more nearly to the axis of the land drainage, the resultant will be increased and the water be deepened. (This suggests a remedy for Galveston and other points.)

The charts show moreover that obstructing the entrance to all of these ports, there are found bars, which, in their unimproved condition, seldom lie more than 12 feet below the surface. To open and maintain a permanent channel over them, is a problem which has long engaged the attention of engineers, and upon which millions of money have already been expended with but little success.

The Relations of Cause and Effect.

In all physical problems, before attempting to apply a remedy, it is first necessary to determine the forces and agencies which have combined to produce existing effects, and to ascertain whether they are permanent or constant in their action, and whether constructive or destructive in character.

It thus becomes a fundamental duty of the engineer to collect rigorously all the data relative to the case, and to determine from them the mutually dependent relations between cause and effect. This must be done not only for a particular phase or condition, but for an extended series of changes under as nearly as possible all conditions. Just here is found one of the chief causes of failure of such works; constructed hastily and in emergencies, to meet existing conditions, they are soon destroyed or rendered useless by some unforeseen physical change.

A single survey of a harbor, however complete, cannot furnish all the necessary information. There should be a series of such surveys at times of greatest and least disturbance, and extending over a number of years, to exhibit comparative changes, and show the relative movements both in amount and direction.

Suggestion as to Hydrographical Charts.

To render these observed facts more legible, it would be much better to represent the submarine topography by shaded zones, representing the surfaces included between the various fathom contours, instead of, as now marking them, by an intricate system of dotted lines, which become intelligible only by following each one through all its meanderings immediately to lose it again in the multitude of its deflections. By these shaded or colored zones, increasing in intensity, and separated by contours at regular intervals, the form of the bottom mould is at once revealed, and when it is remembered that *in alluvial formations this bottom is plastic, and therefore the resultant or effect of all the forces acting upon it, it will be seen how important a key it furnishes to the correct interpretation of the agencies which have produced it.*

Moreover, maps of the same locality should be plotted upon the same scale and, if possible be, at nearly equal time intervals—say every five or ten years. The contours should also be at regular intervals. By these means the data collected would be made more valuable and intelligible, and some definite laws could doubtless be deduced which would be of general application. A convenient scale for small harbors would be that generally used for surface topography, 400 feet to 1 inch $= \frac{1}{4800}$.

If contours be drawn every three feet or at half fathom inter-

vals, then by making wooden models of the volumes included between these mid-fathom lines, a convenient method is furnished for determining by weight the amount of work done by the different strata of water.

The Forces

which act either singly or in combination to mould the harbors, are those due chiefly to wind and water in every possible condition of activity, and affected by terrestrial or universal gravitation and temperature. Or more specifically, they are, the ocean, with its flood-tides, littoral currents, waves, inertia and winds on the one side, and on the other, the ebb-tides, land-drainage, currents, and winds. These opposing forces in continual conflict, are materially affected by the topography of the field-of-battle. The results of the last severe contest will also modify the next. The direction and intensity of the attacking and opposing forces are constantly varying, and any attempt, therefore, to formulate them, must result in utter confusion. It can only be said that the resultant action at any instant is a function of the forces acting at that instant, and that these are independent variables, whose values cannot be exactly determined.

Physical Laws.

There are, however, a few physical laws which will serve as a guide to a general solution, when aided by close observation. They are:

1. The resultant effect is that produced by the effort of "Nature" to establish and maintain an equilibrium. Any improvement should therefore aim to aid and not to oppose her.

2. That a force will carry a lesser load up hill than it will roll down. Hence it will be found that the gentler slopes will face or oppose the current and the steeper ones the overfall. Thus, by an inspection of the section of the bottom, it can generally be determined which way the resultant current has been moving and from whence came the sediment. This can also be verified by taking the specific gravities of specimens from various points on the section, when it will be found that the heavier materials being the first to be deposited, will indicate the direction of the movement.

3. That the discharge of the ebb tide being augmented by the land drainage, is greater than that of the flood when not affected by local conditions.

4. The location where the opposing sea and land forces are most nearly in equilibrium, or where the *regimen* is constant, will be indicated by the relative permanence of the bottom.

5. The immediate front or line-of-battle will be well defined by the deposits which barricade the entrance to the harbor, forming a chain of submerged breastworks which the opposing forces alternately storm, and from which each in turn retires as its opponent becomes reinforced by the tides or winds.

Even where there are no tides, but merely winds and waves opposing the land discharge, as on the great lakes, these bars, points, spits, or hooks, are a characteristic feature at certain points, especially where ice is driven by wind towards the mouth of a river. One of the most conspicuous of these is Minnesota Point, at the head of Lake Superior, where a narrow sand-spit, of about six miles in length, makes and protects, as by a breakwater, a harbor of equal length and one mile in width.

6. These natural agencies may be materially interrupted or affected by artificial constructions, so as to cause the land forces generally to preponderate, and thus secure a resultant movement in one direction, and that seaward.

7. That by contractions of a channel the scouring and carrying capacity will be increased, and conversely by enlarging, it will be diminished. This may be accomplished by the usual jetty construction, or by bottom dikes, but still better by a vertical deflection of the most energetic part of the current in a manner to be more fully explained hereafter.

8. It is easier to deflect or divert a force than it is to oppose it. To secure this result a floating, flexible curtain has been devised, which is out of reach of the most violent wave action, and only affects the flow of the currents intended to be diverted.

9. Flowing water will follow the lines of least resistance and greatest declivity, and when collected in streams or currents, will follow the thalwegs of the slopes.

10. The resultant of a system of forces which are in equilibrium may be changed in direction and intensity by modifying the component forces.

11. That any submerged obstruction to a tide or current, which creates an overfall or produces lateral currents, contains the elements of its own destruction, by undermining.

As this principle does not appear to be fully recognized, it is desirable to be more explicit. Let us suppose a current to impinge at right angles to its axis upon a jetty built to half low-water. On coming in contact with the sloping face it is separated into its components up and down the slopes. The upward components are urged on by the overlaying strata, and being forced over the crest, eddy down the opposite incline to the bottom, where, rolling like a cylinder, they grind out the sand and throw it over in the channel.

If the axis of the stream be inclined to that of the jetty, then in addition to the overfall scour there will be strong lateral currents developed on both sides of the jetties. The resultant direction of the currents passing over the crest will be a helix, with greater or less pitch, depending upon the united velocity and inclination of axes.

It follows, therefore, that if a contraction can be secured by a device which does not rest upon the bottom nor even touch the shores, but floats on the surface, it cannot be destroyed by being undermined. Such a system will be found to possess numerous and great advantages over those now in use.

12. In tidal waters submerged jetties permit the dissipation of the most vital part of the force they are intended to conserve. They permit sand to be swept over their crests by the flood (for the material of the bar is mainly beach sand, not river sediment), only to impede the outflow of or require additional work from the ebb by which it may be removed. If the ebb be not strong enough it must remain a permanent obstruction in the channel.

In fact, that portion of a submerged jetty which is on the bar acts as a dam to still further diminish the available water-way, and unless the velocity of the current as it emerges from the inlet or gorge be maintained by a continuous support until it reaches the bar, it will be dispelled and the bar will shoal up.

Thus it will be seen that there is on the part of the land forces a tendency to scour out a channel, and of the naval forces to build a bar. Our efforts must therefore be allied to the former

and opposed to the latter. The amount of the scour or the depth of the channel will therefore depend very largely upon the topography of the bed of the harbor and of the adjacent territory, as that materially influences the tides, the volume and rapidity of discharge, the form and position of the bars, and the character, extent and location of the auxiliary works of improvement.

It is also manifest that dredging alone will not in general produce a permanent effect, but the dredged channel will simply serve as a sump for all that drifts into it, and will soon be filled up.

The Analogy.

The action of the winds and waves on a sandy bottom may best be compared to that of the snow storms of our western prairies. There it is invariably found that the windward slopes are swept clean, while to the leeward of obstruction, even though they be merely fences, the snow curls over and is banked up in drifts many feet deep. The overfall or swirl of wind scours a deep channel close up under the lee of the house or fence, but just beyond there is the compacted mass of almost impenetrable snow. A country road in open, level ground, will be found packed full of the snow which has been carried over and between the bars or rails of the fence to leeward—while to the windward the fields are swept clean. The slight interference caused by the open fences reducing the velocity and changing its direction, precipitates the snow just where in this case it is not wanted.

So generally is this action recognized that in the location of all railroads an effort is made to keep the grade a few feet *above* the general level of the prairie, and where this is not possible, three or more rows of snow fences or hedges are placed on the windward side of the track, at intervals of 150 to 200 feet, to catch the snow before it reaches the cut. With snow-drifts the accumulation does not extend beyond one winter, as the heat of the succeeding season entirely dispels them, but with the ocean the action is more constant, and hence whenever barricades are erected to resist her forces, they must be made so permanent, be so placed and so *high* as to compel a continuous change of base to the rear.

It may be objected that such a policy involves a constant expense. This may be true, but only to a limited extent, for it

should be remembered that nature, having been abandoned to herself for many centuries, has by so much the start, and has had time to thoroughly intrench herself, but so soon as the approaches are completed to the outside of the bar, then only a very small expenditure will be necessary to maintain and extend them in places, where there may not be ample "dumping ground" beyond. In many localities the topography may be such as to cause the scoured material to be dissipated by littoral currents, and a permanent channel will thus be secured without additional cost, and generally the water passing through the gorge to the sea, has deposited most of its sediment in the inner bays, and the bars are formed from the sand carried up by the "flood." Keep that sand out and the formation of bars in the channel will be prevented to that extent.

Otherwise these unceasing natural agencies must be allowed to continue uncontrolled and uninfluenced by works of man, and the result will be a barricaded coast line, strewn with the wrecks of the lives and fortunes of "them that go down to the sea in ships, that do business in great waters."

The Resultants.

Before deciding where, when and how to dispose of our re-inforcements in this contest with the sea, it will be necessary to learn something more as to the strength and position of the aggressors. These ocean forces consist of,—1. the Gulf Stream flowing from the Florida Keys, where it has a velocity of 3 to 5 miles per hour, diminishing to about 1 mile off Hatteras, as the stream expands. The walls of this stream are well defined, and its force is very variable both in direction and intensity. Its bed is beyond the 100-foot contour.

2. Between it and the shore-line a cold Arctic current extends along the entire coast, flowing in a direction opposed to that of the Gulf Stream, thus forming along the inner wall numerous eddies, and along the coast complicated littoral currents.

3. These streams are both modified by the tidal wave with its diurnal variations of ebb and flow.

4. There is also the opposition to the fresh water discharge, which is impounded by the ocean in lagoons, bays, sounds and

estuaries—where its sediment is mainly deposited before reaching deep water.

5. The forces of winds and waves separately or in conjunction, acting both above and below the surface.

These may be taken, for the wind, at 50 lbs. per square foot, and for the waves, at from 2 to 3 tons. This latter force is relatively small *below* the surface, as it is there resisted by the inertia of surrounding particles, making an impact under water difficult; but above the surface it is projected with great violence through a less resisting medium upon any obstruction it may encounter. Experiments made at Oswego Harbor Breakwater during a storm gave the following pressure upon a dynamometer attached to its face and fully exposed to the N. W. gales. At surface, 960 lbs. per square ft., 8 feet below, 25 lbs., 16 ft. below, nothing; and at another time, at 8 ft. above it was 950 lbs., at the surface, 900 lbs., and 8 ft. below, zero. The depth of water was 30 to 36 feet.

Another series of experiments were conducted on Lake Michigan to determine the effect of the wave action upon sand at various depths, as follows. Boxes were placed on a shelving bottom at depths of 6, 12, 18 and 20 feet, and anchored. After a storm the highest one was found to be full of sand, the next about half full, the third contained very little, and the last none. They were spaced at regular intervals, extending 2000 feet into the lake.

"The effects of the wind alone are manifest in the movement of the sand dunes, sometimes 100 feet high, on Carrituck Beach, burying under them huts, trees and shrubbery, and filling up the sounds. The course on this part of the coast is known to be southwest. The direction is always indicated by the steepest side, which is under the lee of the dune. The following general resultant of gales, in 1875, will show the direction and intensity of prevailing winds during that year at the localities mentioned:

Norfolk, Va., 310 miles towards, . . .	N. 74° 18′ E.
Cape Henry, 8587 miles " . . .	S. 9° 56′ W.
Kittyhawk, 16,732 " " . . .	S. 35° 35′ W.
Cape Hatteras, 5697 miles " . . .	S. 80° 30′ W.
Wilmington, N.C., 4154 miles towards, .	N. 40° 48′ E.

* Report, Chief of Eng., 1876. Report of S. T. Abert, U. S. C. E.

The resultant being largely from the N. E., corresponding with the movement of the dunes to the S.W. Hence a careful inspection of topographical feature will often reveal the general direction of the forces.

The general condition of stability along the North Carolina coast is shown from the following table of depths at principal inlets:

	1708	1738	1775	U.S.C.S. 1875.
Hatteras	15.0 ft.	7.0 ft.	—	14. ft.
Ocracoke	10.0	14.0	14.0	11.5
Beaufort	10.2	12.2	12.2	12.0
Cape Fear River . . .	12.5	15.0	9.5	12.5

Thus in 167 years the first appears to have shoaled one foot; the second, to have deepened $1\frac{1}{2}$ foot; the third, 1.8 foot; and the fourth, to have remained constant, though with intervening variations.

An attempt to cut an inlet through the beach at Nag's Head was made about 1850. Congress appropriated $50,000, and operations were commenced on the plans of Lieut. Woodbury, and continued until May 13th, 1856, when Lieut. Whiting was assigned to the work. Col. Turnbull and he subsequently reported "that $40,000 have been expended, and at this time there is scarcely a trace to be seen of what was done, the drifting sand filling the trench as fast as it was excavated by the dredging machine."

The progress chart, U. S. C. S., of Section III, 1868, shows that a number of bottles, which were dropped overboard along the coast off the Eastern Shore of Virginia, and about 15 miles out, all moved southwesterly to the points where they were found on the beach from two to sixty days later. It will also be seen from the charts that, after debouching from the gorge of the inlets, the channels, when they are not protected by a lee-shore, are bent to the south and southwest. This flexure continues to increase until the channel is crowded over against the adjoining southern lip of the coast, where it fills up to such an extent as to cause the imprisoned waters to escape at some weak points more nearly opposite the gorge, and so renew the cycle.

The general formula for mean velocity is $V = C\sqrt{RS}$, and for the discharge, $D = AV$, and the invariable action of the escaping

water, after passing the mouth of the inlet, is to spread out over a much larger area, having a lesser surface slope, by which both factors under the radical are reduced—and the force due to the velocity is dissipated. In all attempts at improvement on our Southern coast, the object has been to preserve the normal values of R and S at the gorge often by a system of submerged jetties, which for the reasons previously stated have not been successful.

Galveston and Charleston.

For example, at Galveston, Texas, an effort has been made for eleven years, at a cost of about two millions of dollars, to increase the depth of water over the bar, by building a line of submerged jetties on the south side of the entrance, from Fort Point to the crest of the bar, a distance of $4\frac{1}{4}$ miles. When this work of improvement was begun, in 1874, there was a depth of but 12 feet on both outer and inner bars.* In the report for 1884, Chief of Engineers, page 1301, Mr. Ripley says, in commenting on the survey of this entrance: "Upon the crest of the bar but slight changes have occurred. The depth in the jetty channel remains at 13 feet, at mean low tide." This is the greatest depth on the crest, and is limited to a very small area near the outer end of the jetty —so near, in fact, as to make it dangerous for a sailing vessel to try to reach it in a N. E. wind. Thus it may be said that about one foot has been gained in the depth, and that by the local scour or overfall at the end of the jetty, and not by contraction.

At Charleston, before extended improvements were commenced, in 1878, there were $12\frac{1}{2}$ feet of water on the bar, and a carefully elaborated plan of improvements was then forwarded by the Chief of Engineers to Congress, containing this quotation from the Report of the Board of Engineers appointed to consider the plan:

"The channel over the bar can be improved to a probable depth at mean low water of 21 feet by the use of jetties, submerged in whole or in part, and by a mode of construction very gradual in its progress, which will admit of such modification in the lengths and heights of the jetties, as experience shall dictate."† "The estimated cost of the proposed improvement will vary from $1,800,000 to $3,000,000."

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* Page 723, Report of Chief of Eng., 1874, Part I.

† Page 554, 1878, Part I.

And at this stage of the work, we find from the reports and maps of 1884, this statement: "The outer 15 and 18 foot curves of the bar show but little change. The present shoalest sounding along the channel at mean low water is twelve feet."* This is the greatest depth of water on the crest of the bar and between the jetties. Instead, therefore, of 21 feet, the figures are reversed, and a half a foot of water has been lost.

The theory on which submerged jetties is based, and the reason for their adoption, are given in Report of 1878, Part I, page 559, where, speaking of the plans for Charleston, the eminent writer says:† "One characteristic feature of the design, that of low jet-"ties, is intended to maintain the bar in its present general loca-"tion with such moderate increase of magnitude, as may be ex-"pected to result from concentrating upon a gap one-half to five-"eights of a mile in width, a portion of the water which is now "dispersed over a width of 10 miles.

"The complete success of the works is believed to depend on "three important conditions, which they are expected in great "measure to satisfy, and which have been kept in view in pre-"paring the design, viz.:

"1. *They should not impede the inflow to such an extent, as to pre-"vent the tidal basin being filled, as now at every influx of the tidal "wave.*

"To this end the inner half of each jetty, more especially its "central position located in deep water across the thread of the "current, is kept several feet below the water. The outer half, "being nearly parallel to the direction of the flow, is built higher, "and the sea end, for a distance of several hundred feet, may be "carried high enough to be visible at all stages of the tide.

"2. *They should control the outflow to such a degree and in such a "manner that a channel of the required depth will be maintained "through the bar.*

"To this end, although a large portion of the *surface flow* will "spread out over the tops of the jetties and thence over the bar, "the *central flow* throughout the entire depth along the axial line "of the gorge, * * is aided in its natural tendency to reach the

* Report of Chief of Engineers, 1884, Part II, page 1087.

† 1878, Part I, page 558.

"sea along the prolongation of that line by the opening left for it "between the jetties. The *bottom flow* through the gorge of the "harbor is deflected on converging lines by the jetties, and is "therefore forced in a measure to concentrate itself in, and flow "out through, the gap between them."

The above movement in strata, while perhaps simple in theory, is defective in practice, for the reason that no account has been taken of the mould of the bottom, and that before water will run up a hill 68 feet high (which is the difference in level between the bottom of the gorge and the crest of the bar), it will flow over the tops of the submerged jetties, which, at the lower points, is 20 feet below the crest of the bar, or 32 feet below low water. The energy is therefore dissipated in these side issues, and not concentrated upon the gap of the jetties—a sure cause of defeat in such a conflict.

And the third reason for this system is:

"3. *They should not, to any considerable extent, cause a movement "seaward of the main body of the bar; that is, the general position of "the bar should be independent of the effects produced between, and be-"yond the heads of the jetties.*

"It is believed that this condition will be secured by making "the shore end of the jetties low for at least one-half their length, "or throughout those portion which cross the thread of the cur-"rent in deep water, so as to allow the tide to ebb and flow some-"what freely over them. The effect of high jetties, with a corre-"sponding wide gap between them to allow a full influx of the "tide, would tend to transfer the gorge of the harbor from its pre-"sent position to the sea-ends of the jetties and move the shore "line out to that point by causing a filling in of the exterior "angles between the jetties and the shore. After reaching this "stage, a drift and wave bar would probably be found to the sea-"ward of the present bar, in front of the jetties, rendering it neces-"sary to extend them in order to cut a passage through it."

Here, then, we find theory opposed to theory and no deduction from numerous precedents, but because a wave bar would probably be formed, therefore the submerged jetties were adopted.

The report further states:

"The drift-material carried along the coast by the surf-currents,

as well as the sand thrown up by the breakers on the north and south shoals, instead of lodging in and filling up the exterior angles between the jetties and the shore, as in the case of high jetties, will be disposed of in a harmless manner."

"For example, a heavy north-easterly storm * * would put in "motion a large quantity of material, a portion of which would "be carried in by the flood-currents over the north jetty, * * "coming to rest in the deep water of the main channel. It would "next be taken up by the ebb current and rolled out to sea be-"tween the jetties," etc.

This disposition of sand we must take exception to as being unnatural, for the reason that it would be necessary to carry the load up a steep ramp with a weak current, whereas there is a line of less resistance and a stronger current in a direction at right angles thereto, during the prevalence of the storm.

The fallacy of the above proposition is further confirmed by the report of the diver, made in 1884. He says, *inter alia:* "As "a rule more stone was reported on the inner than on the sea "side of the jetties. The displacement of the stone appears to be "mainly due to the action of the waves, though in some cases "careless distribution is suspected."

"The sand is almost invariably piled up more on the sea sides "than on the inner sides of the jetties. Considerable scour has "taken place along the channel edges of the outer portions of "both jetties. This is more marked along the north than along "the south jetty. The spurs along the south jetty appear to have "been a protection against scour. The effect of the 'flood' in "piling up sand is greater than the ebb, in the immediate vicin-"ity of the jetties."

Thus we find confirmed the proposition No. 11 concerning the scour produced by submerged jetties, as well as the general statement in regard to the direction of the resultant of all the forces being from the N. E.

Yet in the face of these facts it is proposed to build a half tide dike, 5 miles long, at the entrance to the lower bay of New York Harbor, and so create a general disturbance of all the channels which are considered "permanent and improving." This is a case where a local concentration of forces upon some one outlet would be, in our opinion, a far more successful treatment.

Such local treatment can only be made successful after a complete physical survey of the immediate channel to be improved, showing its relation to all modifying forces and influences. No deductions of great value can be obtained from the general direction of ebb and flood tide, nor of mean velocities, as it is found that there are numerous independent streams in every estuary, which are very variable in their action under different conditions of wind and tide. Thus at Cromarty Firth, where the gorge is 4500 ft. wide and 150 ft. deep, it was found that while the surface velocity was but 1.8 miles per hour, at 50 ft. depth it was not less than 4 miles during the flood tide, and during the ebb the surface velocity was 2.7 miles, and that at 50 ft. depth it was 4.5, so that no deductions from surface velocities would have been of much value.

Part II.

HARBOR STUDIES.

Application to New York Entrance.

By Prof. L. M. Haupt, Active Member of the Club.

Read February 6th, 1886.

At New York Harbor nature has made special provision for an excellent channel, but as yet the problem remains unsolved. An inspection of the maps of the lower bay shows several peculiar and anomalous conditions. The first is the flexure of the outer ends of the various overflow or waste weir channels to the northward, or in a direction contrary to that existing along the southern coast, as has already been shown. This indicates a resultant current along the Jersey shore in a northerly direction, and accounts also for the existence of Sandy Hook. The bar to the N. E. of and adjoining the Hook also affirms this supposition, as it is formed on the neutral ground, where the discharge from the main channel encounters this strong flood current. The resultant of these two forces is then met a little further to seaward by the water of the "Swash Channel" at an angle of about 45°, and

at the same time that a portion of the ebb is flowing the flood is coming north past the Hook, producing an *eddy* with an axis of rotation nearly vertical, and having a movement in a direction nearly N. and S. over a distance of about 1¼ miles. The effect of this is to cut out a hole or basin through the eastern part of the dry Romer Shoal, reaching to nearly 52 ft. depth, with a length of about 1¼ miles and average breadth of 300 yards, or, taking the general dimensions *below the five fathom curve* to be 2100 x 300 x 4.5 yds., the contents of this hole will be about 2,830,000 cubic yds.

This is not merely a temporary freak of nature of recent origin, but a resultant of all the forces which have been acting upon that section of the harbor from, and before, the date of the earliest coast survey, about 1835, when this basin is shown extending north from the western end of Gedney's Channel and very nearly at right angles thereto. Comparison of the several charts show but slight changes during the past thirty years.

Some of the U. S. C. S. reports upon New York Harbor call special attention to this remarkable hole, but do not offer, so far as we have discovered, any reason for its existence.

Here then we find a reservoir of pent-up forces at the head of the channel, which it is proposed to deepen by dredging at an estimated cost of $350,000, but no attempt is proposed to be made to utilize this power for assisting in opening and maintaining this channel. On the contrary, as before stated, it has been proposed to change the present regimen of the harbor and all existing channels, by building practically a submerged dike of about 5 miles in length, at a cost of about $5,000,000, to contract the waterway and increase the mean velocity of the discharge, thus forcing the bar farther out to sea, with no more certainty of producing a single deep water channel than at present.

It is a well-known law of mechanics, that *any system of forces in equilibrium may be changed both in direction and intensity by modifications in the component forces.* Hence, if we can intercept or change any of the forces acting upon the resultant at the head of Gedney's Channel, so as to change the direction of that resultant, and turn it into the axis of the channel, there will be no doubt of its ability to make and keep an excellent open-

ing into the harbor of New York, and unless this force is so modified, the mere dredging of a channel will prove to be of but temporary benefit to the commerce of this great metropolis. To dredge a channel of 1000 ft. in width and 4000 ft. in length, giving thirty feet of clear water at low tide, would require the removal of 700,000 cubic yds. measured in place. This is just about *one-fourth* the size of the hole made by the natural forces close at hand. All that is required, then, is the judicious expenditure of a small fraction of the money estimated to be necessary at this entrance, for the purpose of putting into execution the *local* constructions which may be found necessary to deflect these forces in such a direction as to open and maintain this channel.

It is believed that the expenses may be still further greatly reduced by a recently invented automatic dredge, producing a violent scour similar to, but greater than that induced by contractions in large rivers.

The physical hydrography now in progress by the U. S. Coast and Geodetic Survey should be sufficiently complete to furnish all the data for the correct solution of this interesting physical problem, when completed.

To confirm, if possible, the theory as to the cause of the deep hole on the bar at the entrance to New York Harbor, search was made of records in the office of the U. S. Coast Survey, and there was found a manuscript report of Prof. Henry Mitchell, Assistant, of a survey made in 1858, with numerous diagrams and tables relating to tides and currents, also charts showing the resultant scour of the current during a period of 24 hours at numerous points in the lower bay, and at various depths, from the surface to 24 feet. This report, so happily confirming the previous deductions based upon the mould of the harbor, has never been published, but the following extracts will serve to verify the conclusions as to the causes of the hole, and to show the need in this case of a purely local treatment.

"The bar of New York is not, strictly speaking, a river delta—it is not composed of the muds brought down by the Hudson, but of quartz sand in every respect resembling that of the New Jersey shore. * * The river current takes an active part in the arrangement of the materials which it finds in its path."

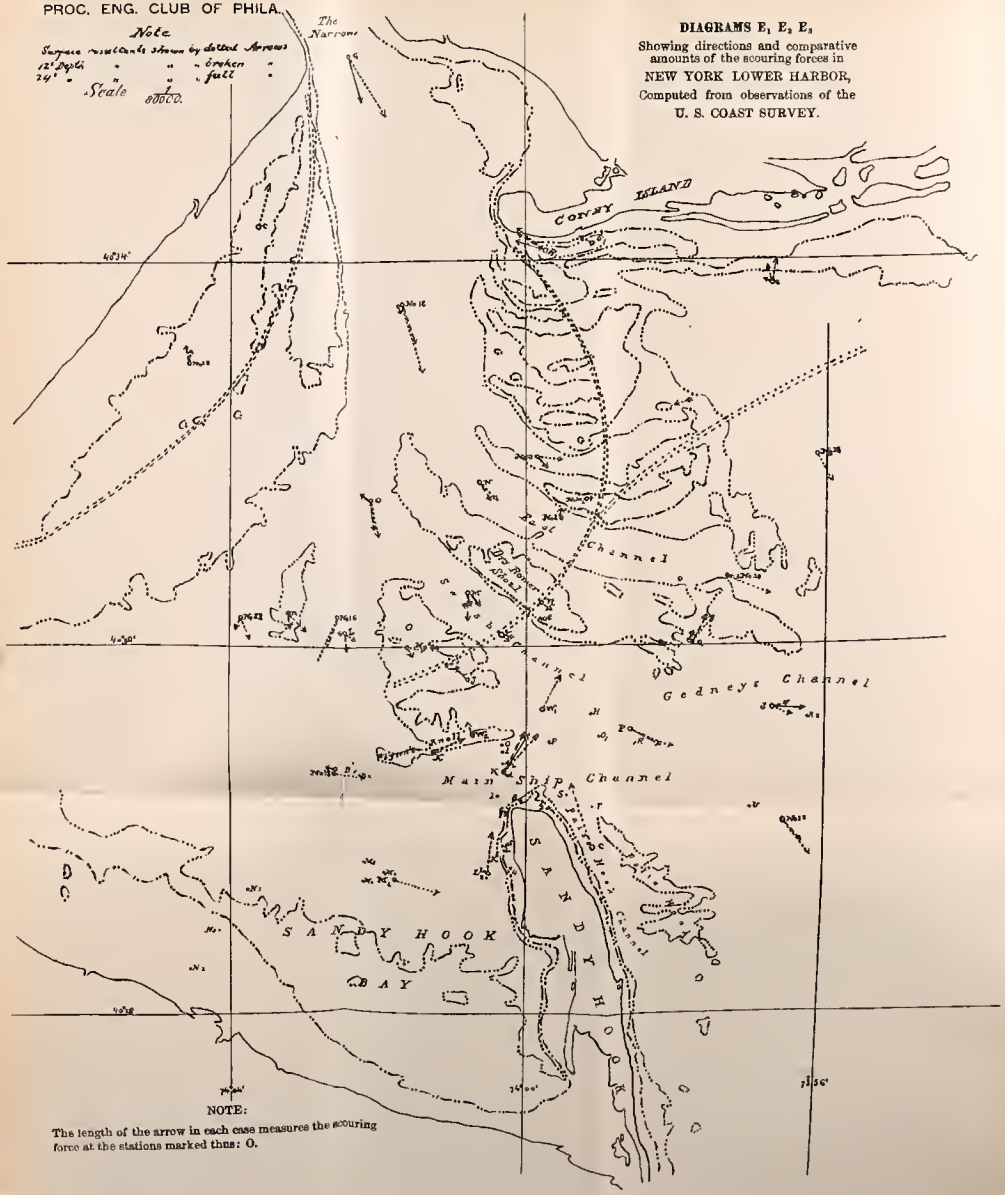
DIAGRAMS E_1 E_2 E_3

Showing directions and comparative amounts of the scouring forces in

NEW YORK LOWER HARBOR,

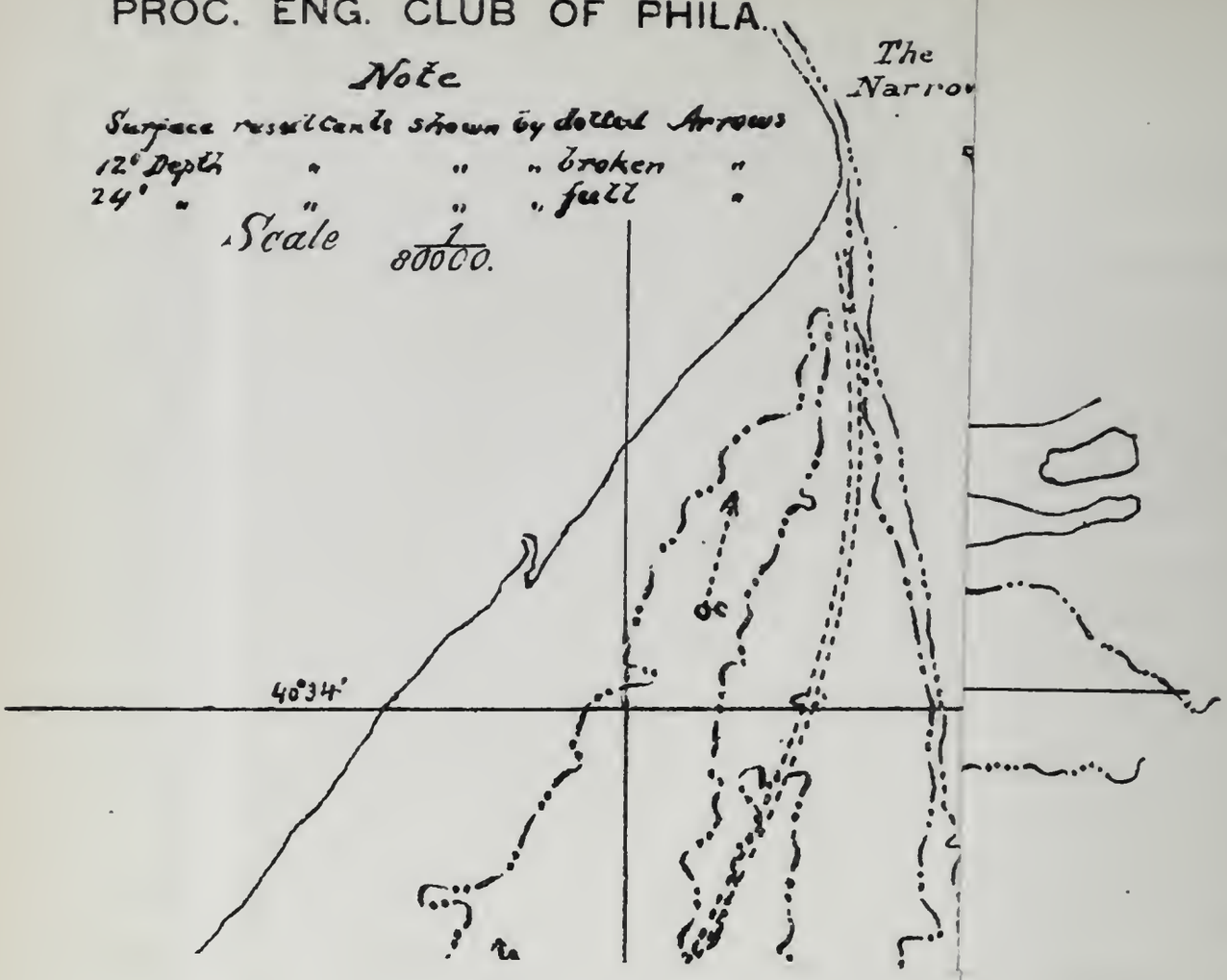
Computed from observations of the

U. S. COAST SURVEY.



NOTE:

The length of the arrow in each case measures the scouring force at the stations marked thus: O.


Note
Surface resultants shown by dotted Arrows
12' Depth " " " broken "
24' " " " full "
Scale 1/80000.
The Narrow
40°34'

"The quartz sand on the bottom moves forward in ridges, precisely in the same manner that dunes travel upon the shore: the sand rolls up a long slope, then, on reaching the top, falls over a precipice." * * *

"As a general rule, the forms of the channels indicate the nature and power of the scouring forces." * * *

"To ascertain the directions and relative amounts of *scour* for these stations, we have compounded the hourly velocities and developed the resultant and its azimuth in each case. In doing this we have used the most general equations for the composition of forces, so that the data have been faithfully used, and the proper weight given to each observation taken from the record. The arrows upon the diagrams are plotted from these results. Diagram E exhibits the comparative scours as calculated from the motions of a superficial stratum. Shaded bands connect the stations where the least scour obtains. * * * The currents crossing the banks on the outer portion of the bar have surface resultants of considerable power."

"The central part of the Swash Channel is but feebly scoured by the currents, and we cannot believe that, if the summer regimen of the rivers maintained, this channel could be kept open."

"The avenue between the Eastern and Gedney's Channels is scoured by the deflection of the flood, which impinges upon the Romer. The resultant takes a northeasterly course in this channel."

"Upon Diagram E_2 and E_3 are plotted the resultants of motions at twelve and twenty-four feet respectively. The most general facts are the same upon these as upon the surface sheet. The curve of least scour crosses the localities of least depth."

"It would appear that 24 feet is the limit of the river scour; but in the vicinity of Gedney's Channel the combined powers of the two bays still gives us an active resultant. Our table gives a few resultants for 35 feet, which is below the transition plane for the counter forces." * * *

"*The localities of least scour are not always those of least action,* in other words, points of great activity are not necessarily those of effective work. On the middle ground, near Flinn's Knoll for instance, we have strong currents, but the ebb and flood are

so nearly equal and opposite at each station, that the resultant is feeble, and no removal of material can take place. The same locality illustrates another important fact, namely: that the *direction* of the scour may differ widely from that of the flood or ebb. It may bisect the angle between the last two. In a case like this, observations and calculations of a less careful character than those we have instituted would deceive us entirely." * * *

"With the aid of facts like those we have detailed, the intelligent engineer designing to deepen channels, or to erect structures in the sea, may determine at what points his operations are likely to be successful, for his aim will be to secure the co-operation of natural forces, or not to oppose them materially. There are some parts of New York Harbor where the good offices of Nature can be quickened by artificial means, at others no human efforts can avail."

The diagrams referred to are reproduced herewith, showing the resultants at the surface, at 12 feet and at 24 feet. From these it appears that the *aggregate force is greater at the head of Gedney's Channel than at any other point on the outer bar.*

In further confirmation of this statement, the following extracts are taken from a report of Prof. A. D. Bache, Superintendent of the U. S. Coast Survey,* where, under the title: "*Normal Currents at the Entrance to New York Bay,*" he says:

The *eastern group* of stations, comprehending the positions R_2, R, Q, and H (see Sheet I), show the currents at and within the bar in the vicinity of Gedney's Channel; the *middle group*, embracing the stations P, O, I, A_2, A, between the eastern portion of Flinn's Knoll and the point of Sandy Hook, shows the current of this part of the Main Ship Channel, while the *western group*, B and B_2, gives the currents for the western part of the Main Ship Channel in the vicinity of Southwest Spit.

"About fifty-six minutes after high water at Sandy Hook, the ebb current begins to make in the eastern group, running east by south, reaching its greatest rate of about 1.71 miles per hour (in about three hours), and then decreasing (in about three hours) to zero and turning to flood at about 1h. 33m. after the time of low water, the ebb thus being estimated at 6h. 19m. The flood reaches its maximum in about three hours, when its rate is 1.11 miles per hour, running generally northwest for about 5h. 43m.; and reaching slack water about 56m. after the time of high water at Sandy Hook. The flood exceeds the ebb, for stations near Gedney's Channel, by about 34m., and the greatest rates are as 17 to 11; the average, as 10 to 6."

"The scouring done by these currents will vary with the product of the duration

* Page 197, Report of 1858.

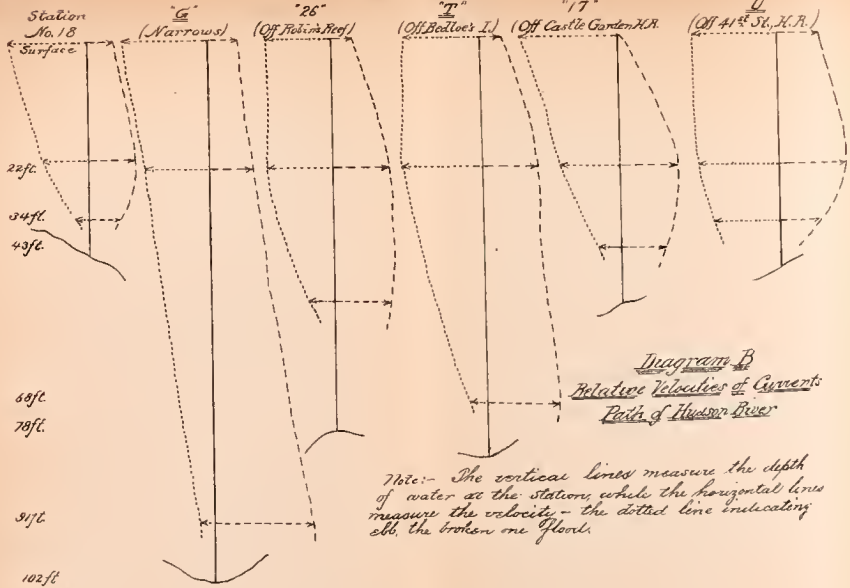


Diagram B
Relative Velocities of Currents
Path of Hudson River

Note:- The vertical lines measure the depth of water at the stations while the horizontal lines measure the velocity - the dotted line indicating ebb, the broken one flood.

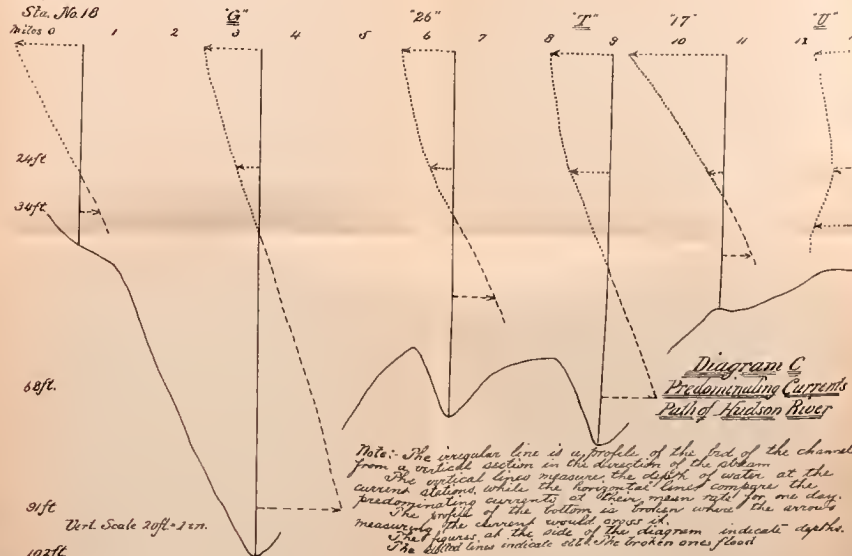


Diagram C
Predominating Currents
Path of Hudson River

Note:- The irregular line is a profile of the bed of the channel from a vertical section in the direction of the stream. The vertical lines measure the depth of water at the current stations, while the horizontal lines compare the predominating currents at these points for one day. The profile of the bottom is broken where the arrows measuring the current would cross it. The figures at the side of the diagram indicate depths. The dotted lines indicate ebb, the broken ones flood.

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and the square of the mean velocity, if the material to be acted upon be the same. In the *eastern section*, therefore, the work done by the ebb is to that done by the flood as 45 to 1.

"In the middle section it will be as 9 to 1, while in the western section the feeble labors of the ebb and flood are nearly equal, and their directions so nearly opposed, that little ultimate scouring is affected. The form of the bottom is in accordance with these results. * *

"The ebb current, with its concentration of forces, is a far more powerful agent than the flood; its scouring capacity along its normal course must be more considerable, and it creates more extensive draught-currents. * * Again, the ebb stream holds its course across the middle of shallow basins in a narrow stream, while the flood, dispersive in its character, pursues the broadest possible path and presses along the shores. * * * The ebb is the primary working agent, and the characteristic features of all channels and basins, on alluvial tidal coasts, must as a rule reflect the efforts of the ebb current."

From these extracts it will appear that the plans proposed for improving the channel on the outer bar, should aim to conserve and increase the scour produced by the ebb currents, and that the point where such local treatment would be most successful, is at the head of Gedney's Channel. The reports also show at what stage of the tide and at what depths the greatest scour is produced, and thus enable us to make the application at the proper time and place.

The diagrams showing Relative Velocity of Currents, are not given in Prof. Mitchell's MSS. report for the outer stations, but those from the Narrows up to 41st, Hudson River, show some characteristic features of tidal water worthy of more than a passing notice.

Thus on Diagram B it will be seen that the velocity of the ebb is, as a rule, much greater than that of the flood at the surface, but their ratios are far from constant, and they are independent of the depths. At 22 ft. depth the velocities of ebb and flood are more nearly equal, and as we approach the bottom, the ebb predominates, in the longitudinal section, from Station 18 until we pass Castle Garden.

Diagram C gives the resultant or predominating current at various depths for the same stations, and shows a profile of the bottom. From this it will be seen that the transition plane, or surface of no resultant scour lies between about 30 and 36 ft., and that above this plane the ebb forces prevail, while below, the flood are the most active. Material deposited in this section of

the main channel would therefore be carried up towards the city. To produce a scour in the opposite direction, the river must literally be turned upside down, or the *ebb* must be deflected upon the bottom.

The profile of the bottom between Station 18 and the Narrows shows a descending slope up stream of about 60 feet in 3 miles, or 20 feet per mile, down which the heavier sea water runs with considerable velocity. The momentum thus acquired carries it up the opposing ramp of 18 feet per mile to a crest 57 feet under water, from whence the profile rises by a series of undulations to a point 48 feet under water, and about 11½ miles from its initial point. Here the flood resultant vanishes, in consequence of the resistance of the bottom friction, and the opposition of the ebb, by and into which it is reflected, giving a stronger surface resultant at Station 17 than at any other point.

Permanency of the Channels.

In describing the entrance to the harbor in 1857, the Commission, consisting of Gen. J. G. Totten, Chief of Engineers, U. S. A., and Prof. A. D. Bache, Supt. U. S. C. S., says:

"Across New York entrance, below Sandy Hook and Coney Island, lies an extensive bank intersected by five channels. * * The Main Ship Channel is next north of Sandy Hook, its direction is due east, and its width 1050 yards, the passages from it through the outer bar are by Gedney's Channel with 23½ feet, and by the South Channel with 23 feet at mean low water. North of this is Flinn's Knoll, covering an area within the 18 feet curve of 852 acres. North-east of Flinn's Knoll lies the Swash Channel, the general direction of which is south-east by south, gently curving from its upper entrance so as to pass more eastwardly; its average width is 900 yards and through it 21 feet can be carried. * * North-west of the Swash Channel is the Romer Shoal, and north-east of this shoal is the Eastern Channel, 750 yards in width, running south-east for half its length, then east and passing over the outer bar with 19 feet of water, a remarkable slue running nearly due south, connecting this with Gedney's Channel. Next to the north-east is the Middle Ground Shoal, covering 1548 acres. Next the Fourteen Foot Channel, running to the south-east and closed by a wide bar with 14½ feet upon it. Then the extensive East Bank, covering 3063 acres. Finally the slue close to Long Island Shore. This entire bank, through which the channels are cut, is of sand similar to that of the beaches of New Jersey and Long Island, the river deposits taking place higher up the bay. The direction of these channels and shoals show, in a general way, the directions of the forces of the water acting at this entrance. The tidal currents of the ebb, reinforced by the affluents of New York and Raritan Bays, displace the sand which the flood deposits, and the channels thus measure the forces of these affluents."

From this description it appears that since Gedney's Channel is the deepest and shortest, the forces acting there must be the greatest. It is also evident that the scouring forces diminish in going northward, as the successive channels are found to decline in depth and breadth, while the bar becomes more extensive.

From a survey made under the direction of Col. G. L. Gillespie, U. S. Engineers, in August, 1884, or about 30 years later, we find that the result "does not very appreciably vary from that of 1883, and shows no decline in the channel." The survey of 1883 referred to was made by the U. S. C. and G. S., and represents the 24-foot curve north and south of the bar in Gedney's Channel, as separated over a distance of one-quarter of a mile, with intervening soundings of 23 feet in small areas. The sailing directions call for only 23 feet, mean low water.

It is also noted, with reference to the advances and recessions of Sandy Hook through considerable distances, that "the channels were only reduced in width," and there was "produced no appreciable changes in the depths of the channels near the Hook." No mention is made of the "sluice," or basin, at the head of Gedney's Channel, though the chart shows it with 51.9 feet of water.

Current observations made at the west end of this channel gave for the maximum velocity of the ebb $1\frac{1}{2}$, and for the flood $1\frac{1}{3}$ statute miles.

"The set of both maximum ebb and flood is almost directly along the axis of the channel. * * The float was a cylinder of wood, three inches in diameter, weighted so as to maintain its lower end near the bed."

A Board of Engineers, in forwarding Col. Gillespie's report and survey, in a report made to the Chief of Engineers, December, 1884, says with reference to these channels:

"Immediately north and east of Sandy Hook is an area of about 2 square miles, having a depth of 30 feet or more. Two channels, Gedney's and South Channels, each having 24 feet or more, enter this deeper area from the sea. One channel, the Main Ship Channel, leads from it first westerly and then northerly to the upper bay, and another, the Swash Channel, cuts off an angle in the Main Ship Channel, and thus gives a shorter route to the upper bay.

"North of the Swash Channel, in order, are the East Channel and the Fourteen-foot Channel, both closed at their sea ends by bars of 20 and 17 feet, and lastly, a channel close under Coney Island, closed by a bar having 16 feet at its harbor end."

From this statement it will be seen that the channels near the Hook have slightly improved, while those above Gedney's Channel have shoaled, the first or East Channel one foot, the next, or Fourteen-foot Channel, by two feet. The Coney Island Channel is one made and maintained by the *flood,* as is shown by the bar at its "harbor end." The natural forces to be assisted, therefore, are those of the ebb currents, *operating on the Main Ship Channel and its outlets.*

The results of the movements of the Hook show that even jetties of considerable magnitude would produce but little scour at depths exceeding 24 feet, near which, as Prof. Mitchell's report shows, the plane of reversion of tidal forces is located. To utilize the ebb, therefore, it must be deflected downwards upon the bottom, and be trailed in the channel.

That the scouring forces are generally limited to the surface planes, is also shown by the depths of water on the crests of the various bars along the southern coast. The position of the crest-line or divide, with reference to the straight line joining the nearest points of shore across the inlet, will also furnish a good idea of the relation of the flood to the ebb scour.

If the crest is outside of this section, it may be attributed to ebb action, and if inside, to flood. At some entrances it will be found partly on one side, partly on the other. At New York, Delaware and Chesapeake Bays, the ebb crest is on the sea side along the southern part of the section, and the land side on the northern. The deepest water is also near the southern cape or hook, outside of which there is a characteristic bar. Where the crest line crosses the section, the forces are about equal and contrary, giving a resultant equal to zero. Hence they cannot be used to advantage in opening a channel. Above this point, efforts should be made to utilize the flood, and below the ebb tides.

The Proposed Dike.

A dike rising to half tide, as recommended, would, we believe, merely result in a removal of the crest of the bar to seaward without necessarily producing a better channel, and if, as is further suggested, it be built "at first certainly not above low water, and,

perhaps, not so high," making it practically a submerged jetty, the result would be disastrous to the dike, as well as to the harbor, from the dangerous obstructions it would produce.

The time required to complete such a dike, with its accessory works, would be very great, as compared with that necessary to erect floating deflectors, such as is proposed, and in positions where all the physical conditions give assurance of success.

The Remedy.

In applying the remedy therefore in accordance with the principles previously stated, that it is easier to deflect than to oppose a force, and that submerged jetties contain the elements of their own destruction, we must conclude that the proper construction would be one the specific gravity of which is *less than that of water*, that is one which does not *rest upon* the bottom, thereby producing a scour by its weight, and by transmitting the force of the waves to the bottom, and which does not extend above the surface, where it would be subjected to the shock from the waves, and from ice. It should therefore be a floating system, which may be adjusted to any depth, so as to conserve and deflect the maximum force of the currents in the proper direction. This can readily be done by anchoring vertical, flexible deflectors obliquely across the paths of the currents, but entirely out of reach of navigation, and adjusting them at such angles as to give the required direction to the forces there existing. The material must be such as will not be destroyed by the teredo, and it should be so arranged that the panels may be readily extended, removed, or replaced. Durability and economy are also requirements, but they are subordinate to those already mentioned, as the expense of maintenance would be very slight. All of these are within the limits of mechanical and physical possibilities, and at a cost which is insignificant as compared with that of the project recently submitted to the Forty-eighth Congress, Second Session, in Ex. Doc. No. 78, to which allusion has already been made.

Such deflectors would occupy but little space, and hence produce the least possible disturbance to the general regimen of the harbor. Their only effect would be to reduce the velocity of the current

across a portion of the bar, where great depth is not required, and to increase it in a channel where it is needed, and by these means cause the hole or basin to fill up in part, and the channel to scour or deepen.

Current Deflectors.

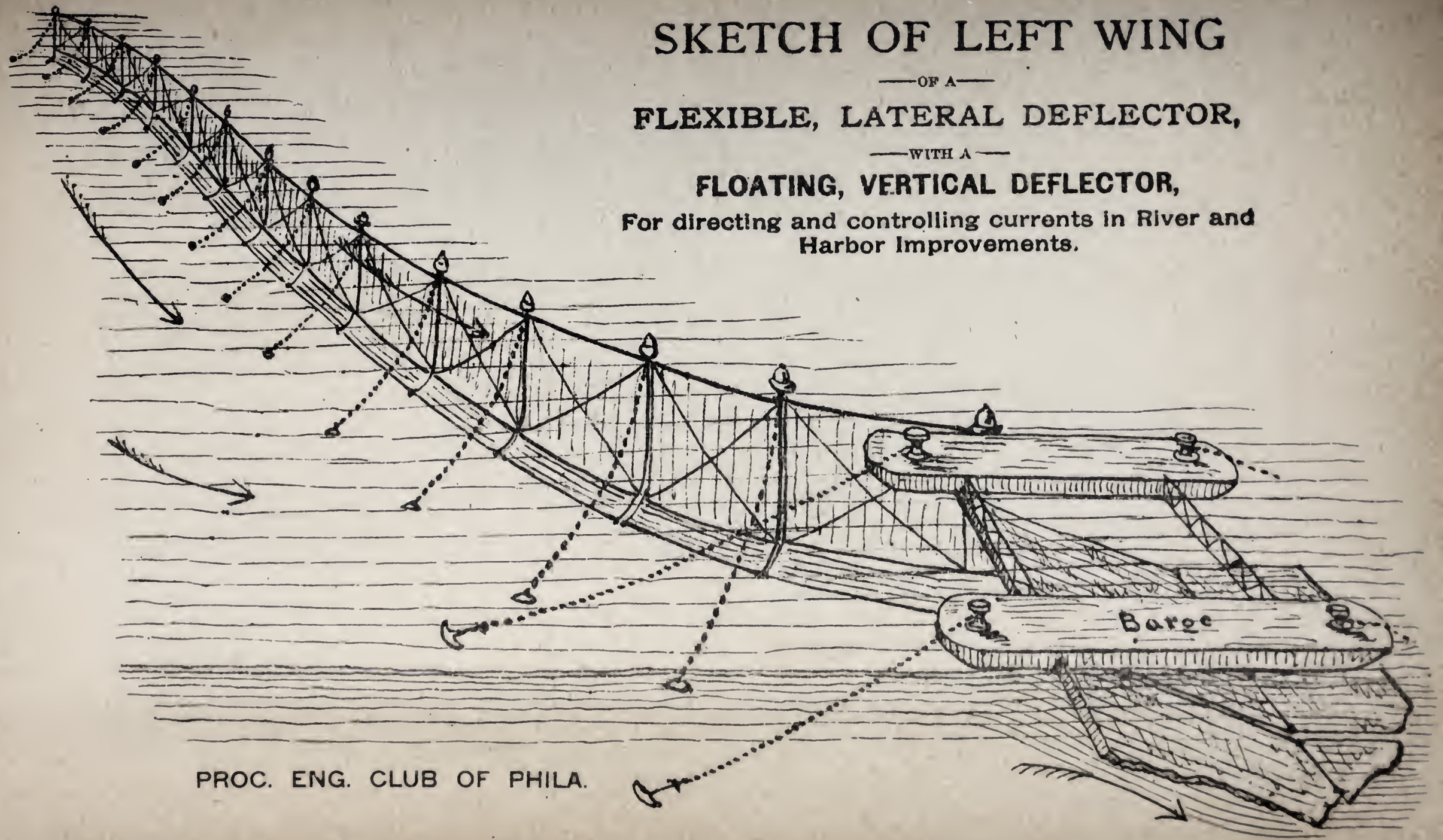
The scouring action can also be greatly augmented by a device for utilizing the *maximum velocity* of the current and projecting it upon the obstruction to be removed. Heretofore an increased scour has, in general, been given to currents by contracting the area of the water-way by dams or jetties attached to, or resting upon, the shores or beds of the streams, and thus the "head" and consequent velocity have been augmented slightly; but the effect on the bottom velocities, where the work is to be done, has not been great. As the greatest velocity of a current is near its axis, and at or just below the surface, we have designed a *floating dam, with an axis of rotation at the surface,* and so suspended to floats, buoys, or bateaux, that by depressing the down stream edge of the shields the greatest force of the current is made to impinge directly upon the bed, and thus produce a powerful scour. The material thus loosened up is directed by "trailing pieces" to suitable "dumping grounds," and the channel thus formed is maintained by other vertical or inclined deflectors anchored to the bottom.

By this arrangement we not only have the increased velocity due to the contraction caused by the floating dams, but that due to the deflection of the maximum velocity of the stream through a head, equal to the difference of level between the upper and lower edges of the shields.

We therefore utilize an additional and very potent factor in the working capacity of the current, which is believed never before to have been successfully applied.

The annexed sketch will show one of the forms proposed for the deflecting shield when supported by barges or pontons, in combination with an adjustable floating curtain for concentrating the currents upon the deflector.

These may be arranged in continuous or broken ranks of any desired length of front, or in echelon, as may be found most advantageous in the attack upon the bar.



SKETCH OF LEFT WING

—OF A—

FLEXIBLE, LATERAL DEFLECTOR,

—WITH A—

FLOATING, VERTICAL DEFLECTOR,

For directing and controlling currents in River and Harbor Improvements.

By such a combination of simple and automatic devices we believe a very effective local application may be made, which will be free from the serious objection to the ordinary methods of treating such cases. It will be seen that it is designed to conserve and control the forces of those *currents* which are the most potent factors in producing changes in alluvial bottoms, and that it is protected, so far as is possible, from the action of winds, waves, ice, teredo, and other destructive agents. It is very economical to construct and maintain, and, moreover, should it be found that, as at first placed, it did not sufficiently concentrate the scouring forces, it can be readily shifted into a new position without injury to the deflectors or to the harbor.

It has the further advantage of being able to be made rigid in one direction, and flexible in the opposite one, so that the flood tide may readily pass over it without opposition, while the ebb will be partially resisted and turned aside into the desired channel.

Having placed such a series of deflecting curtains in position, a few days' observations, with current meters, will indicate the relative changes effected in the directions and velocities of the resulting forces, and enable the engineer to determine what further adjustments, if any, may be required.

It may be suggested that such a structure appears too frail to resist successfully the forces to which it must be subjected. To this it may be answered that ice buoys have been moored in exposed positions in the open sea and in roadsteads for years, without being at all injured or moved by any or all of these forces, and for the reason, which is so well illustrated in the fable of

THE OAK AND THE REED,

that we take the liberty of quoting it for the sake of its application to this case.

An oak, which hung over the bank of a river, was blown down by a violent storm of wind; and as it was carried along by the stream, some of its boughs brushed against a reed which grew near the shore. This struck the oak with a thought of admiration, and he could not forbear asking the reed how he came to stand so secure and unhurt in a tempest, which had been furious enough to tear an oak up by the roots? "Why," says the reed, "I secure myself by putting on a demeanor quite contrary to what you do; instead of being stubborn and stiff, and confiding in my STRENGTH, I

YIELD AND BEND TO THE BLAST AND LET IT GO OVER ME, knowing how vain and fruitless it would be to resist."

Large vessels have frequently been held by a single anchor in the teeth of a gale.

Observed Scour due to Contractions.

With reference to the amount of scour produced by contractions, caused by piers, Trautwine says:

"IT IS IMPORTANT TO BEAR IN MIND, that before the erection of an obstruction the velocity of the original stream is greatest at the surface, and diminishes gradually towards the bottom; but when a pier, etc., is built, the increased velocity produced by the head thereby created, is actually least at the surface, but is *nearly* uniform throughout the entire depth, thus causing a much greater wearing action upon the bottom than before existed, or than is generally supposed. This fact is rarely adverted to by authors. The erection of one or two piers in quite a large stream will frequently produce an almost incredible amount of scour, if the bottom is at all of a yielding nature. The greatest scour, of course, takes place during freshets, and near the obstruction." (P. 570.)

It has also been observed that the position of the thread of maximum velocity in a river is lower when the surface is covered by ice, thus forming a tube, and during the construction of the St. Louis Bridge piers it was observed by the divers that the river bottom "was scooped out under the large scows moored alongside" by just about the amount the scours extended beneath the surface.

Therefore, "If an obstruction be placed in the bottom of a river, thus lessening the cross-section, the surface level will be raised; and if an obstruction be placed near the surface, it would seem as if the bottom or sides must yield."

The annexed table will give the bottom velocities necessary to produce a removal of various grades of material:

APPROXIMATE BOTTOM VELOCITIES OF FLOW IN CHANNELS, AT WHICH THE FOLLOWING MATERIALS BEGIN TO MOVE.

Feet per sec.	Miles per hour.	
.25	.17	Microscopic sand and clay.
.50	.34	Fine sand.
1.00	.68	Coarse sand, and fine gravel.
1.75	1.19	Pea gravel.
2.00	1.39	Rounded pebbles, 1 inch in diam.
3.00	2.04	Small stones 1¾ in. diam.
3.33	2.30	Flint stones, size of hen's eggs.
5.00	3.41	2 inch-square brickbats.

CONCLUSION.

We conclude, therefore, that to remove the shingle and sand from the bar, it will be necessary to develop a bottom velocity of about three miles per hour, and for this purpose there exists at this locality, independently of the forces which have made and maintained the deep basin at the head of Gedney's Channel, a powerful ebb stream, which it is necessary to concentrate and direct. That this can be done, to any desired extent, by the deflectors for surface and lateral contractions, in an efficient and comparatively inexpensive manner, is believed to be established by the accidental experiences already cited. They reveal the existence of powerful scouring forces, located near the surface of the currents, which have not heretofore been attempted to be used in the manner suggested for the solution of such engineering problems.

THE FLOATING DEFLECTOR AS APPLIED TO THE SOLUTION OF THE MISSISSIPPI RIVER PROBLEM.

The Missippi presents one of the most difficult hydraulic problems in the world, and its solution engages the attention of some of our most eminent physicists and engineers. In many places the jetties, wing-dams, dikes, revetments, etc., have worked very satisfactorily, and in others they have been of no avail. We cannot now consider the relative merits of the various general plans for the regulation of the flow, but may merely state that the changes in the bed of the stream, from scour and deposits, are

produced by *differences of velocity.* Where the current is quickened, either by an increase of surface slope, or by contraction of sectional area, the bed will be scoured, and where it is retarded there will be a bar. In high stages the scour is found to be in the "pools," where the bed is narrow, and the precipitation occurs on the "cross-over-bars," where it is wide. In low stages the reverse action takes place from the differences in surface slope. It follows, therefore, that whatever tends to reduce or prevent the deposit on the bars in high stages, will also prevent the scour from the pool below, and to that extent establish a relatively permanent condition, and reduce the bed to a more uniform slope. The proposed deflectors, it is believed, will accomplish this result more effectively and cheaply than any other known device, thus converting what may be styled a horizontal or lateral treatment into a vertical one, and thereby securing the full effect of gravity and momentum in regulating the discharge, by creating and maintaining a more nearly uniform velocity.

Part III.

HARBOR STUDIES.

Delaware Breakwater Harbor.

By Prof. L. M. Haupt, C.E., Active Member of the Club.

Read February 20th, 1886.

The recent severe storms along the New Jersey shore, accompanied by serious losses of life and property, call attention to the necessity for providing some immediate relief and shelter for navigators along this 300-mile stretch of dangerous coast. For humanitarian, as well as commercial and financial reasons, therefor, it becomes an imperative duty on the part of those entrusted with the execution of such works, to inaugurate or complete such measures of relief as may be found to be both expedient and practicable. The only harbor now available in this entire distance, is that at the mouth of the Delaware River. It was projected prior to 1828, and its construction was authorized by an Act of Congress passed May 24th of that year, when the needs of a harbor were insignificant as compared with the present de-

mands; yet its capacity in those ante-railroad days was much greater than at present, in consequence of its subsequent shoaling.

A Commission, consisting of Com. John Rodgers, Brig.-General S. Bernard, and Wm. Strickland, C.E., was appointed by the President of the United States, under authority of the above-named Act of Congress, to prepare plans for an artificial harbor.

The result was a project based upon the experience at Cherbourg, France, and Plymouth, England, embodying all the features of the present structure. The plan was approved by John Quincy Adams, President, on the 27th day of February, 1829. A contract was made soon after with Halsey, Rodgers & Co., and the first load of stone was delivered at 4.15 P.M., Saturday, April 18th, 1829.

The preliminary surveys were made by and the contracts let under the auspices of the Navy Department, but prior to the beginning of construction it was transferred to the War Department. The disbursements were made by the Quartermaster-General. It is now under supervision of the Chief of Engineers, in immediate charge of the officer on duty in this district. Such was briefly the inception of the work.

Location and Description.

This great harbor of refuge is located on the west bank of Delaware Bay, and in the lee of Cape Henlopen, in latitude 38° 47′ N., longitude 75° 06′ W.

It is an artificial harbor, formed by a breakwater of *pierre perdue,* 2558 ft. long on top, and extending in a straight line, which, if produced, would have been tangent to the shore of the cape at the time the work was projected. The distance therefrom was about 4200 ft. There is also an ice breaker 1359 ft. long, making an angle of 146° 15′ with the line of the breakwater, which would intersect it near the middle, if prolonged. Between the eastern end of ice breaker and western end of breakwater there was left a gap of nearly a quarter of a mile. The cross-sections of both are the same, being about 22 ft. on top, 160 ft. at base, and extending to about 14 ft. above mean low water.

The stones vary in weight from a quarter to seven tons. Work was begun in 1829, and by 1839 there were 835,000 tons (about

400,000 cubic yds.) in place, at a cost of $1,880,000; but the structure was not said to have been completed until forty years later, or in 1869, when the total expenditure amounted to $2,123,000.

Effect on Harbor.

The survey of 1828, made by Lieut. Sherburne, U. S. N., before work was begun, shows the 24-foot curve to have been about a quarter of a mile southwest of and nearly parallel to the breakwater, giving ample and good anchorage; whereas the recent surveys of 1879 and 1881 show the same curve winding from the eastern end of the breakwater towards the cape, and near the middle of the harbor there are now but about sixteen feet of water where there were formerly twenty-seven or eight.*

To more clearly illustrate the work done by the forces between the surveys made in 1828 and 1877 and 1881, I have had made † a dissected model (scale $\frac{1}{3600}$), showing the condition of the bottom at these dates, and have determined by weight the amounts of material removed within the zones lying between the fathom planes during these forty-nine to fifty-three years. The results are as follows:

Exhibit of Material Moved in Vicinity of Delaware Breakwater Harbor.

Deposited.

Shore Line to the	Inside Harbor. Cubic yards.	Outside Harbor. Cubic yards.	
6-ft. contour		357,000	Along shore inside of the Cape.
6 to 12 ft. "		890,250	
12 " 18 " "	2,000,000*	1,025,250	
18 " 24 " "	3,407,500	912,000	
24 " 30 " "	2,606,750	606,750	
30 " 36 " "	182,500	365,000	
	8,196,750	4,156,250	
Below 36 "		2,351,100	Part of Breakwater shoal within limits of model.
Above 36 "		621,750	
		2,972,850	
		7,129,100	

* Report of Chief of Engineers, 1882, p. 791.

† By Mr. Samuel S. Evans, C.E., Instructor in Civil Engineering at the University of Pennsylvania.

PLAN OF
DELAWARE BREAKWATER HARBOR,
Showing the topography of the bottom in 1828 and 1881, from Surveys of the U. S. Navy and U. S. Engineers, with sections at the "Base" and the "Gorge," and the velocity curves.
Contours of 1828, thus:
Contours of 1881, thus:
800' = 1"
Scale of current resultants in miles
Scale of Velocity Curves
ft. per min.
Ice Breaker
The Gap
Breakwater
The Base
The Gorge
Bay
Cape Henlopen
Light
Shore Line of 1828
no flood
R. R. PIER
U. S. IRON PIER
U. S. RESERVATION
1828
1879
1881

Scoured.

Between	Southeast end of Breakwater.	Northwest end of Breakwater.		
24–30 ft.			964,500	North of Breakwater.
30–36 "	103,500	75,000	71,250	Hole at east end of Ice breaker.
36–42 "	130,500	30,750	19,500	
42–48 "	51,000	10,000*	6,000	
48–54 "	1,250			
	286,250	115,750	96,750	

From this exhibit it appears that the total deposit inside the harbor has been about 8,200,000 cubic yds. in say the past forty years, since the harbor was not completed rapidly. This gives an average of 205,000 cubic yds. per annum. If the area be taken at three and a half million sq. yds., and the average depth at 18 ft. or 6 yds., it will give a total volume for the original harbor of 21,000,000 cubic yds. Hence the shoaling which has taken place represents about 38 per cent. of the original volume, and the yearly rate over the entire area has been about 2.16 inches in depth. The average depth of shoaling during the forty years will be 7.2 ft. It is not correct to assume that the deposits occurred at this average rate, however, since the shoaling was very rapid during the construction of the works, and has been more gradual since.

The scour from the southeast end of the breakwater of nearly 300,000 cubic yds. represents a portion of the work done by the ebb below the 30-foot curve. It is the result of the "head" due to the contraction at this section.

Plans for Improvement.

The necessity for remedial measures became apparent even before the completion of the work, and numerous reports and plans have been submitted by individual officers and Boards of the Corps of Engineers, and by pilots and others using the harbor, all tending to alleviate the danger of its ultimate and total destruction.

One of these Boards recommended, Feb. 8th, 1878:

* Estimated.

"The closure of the gap existing between the breakwater proper, and its adjoining ice-breaker, which, it is believed, will, to a greater or less extent, check further deposits within the harbor, and remove those existing on the shoals in its vicinity, and will increase the protected area of anchorage nearly fourfold."

The cost was estimated at $600,000.

All the reports since 1836 recommended either the closure of the gap, or its protection by an external apron.

"The arguments for its construction are mainly two, viz.:—1. The necessity for increasing the area protected against N. E. gales, which now enter freely through the gap. 2. The prospect of checking the shoaling behind the breakwater by compelling the large portion of the ebb, which now escapes through the gap to traverse the harbor and pass out by its eastern entrance."

The report states further that "The effect of the former provision is positive in at once doubling the useful frontage of the work. The results, to be anticipated in retarding shoaling between the breakwater and the shore, are less clear."

Among the plans recently proposed was one to prevent the river and beach sediment from being carried in by the ebb from the N. W., by constructing a jetty extending from a point west of the ice-breaker to the shore, and connecting it also with the ice-breaker by extending the latter a distance equal to its own length.

Analysis as to Causes of Shoaling.

Such are the projects. Let us now examine into the causes producing the present evils, and ascertain which of the remedies proposed will be most efficient. Possibly we may be able to add to their efficiency by suggesting some further modification.

It is a maxim in harbor engineering "that no encroachments on tidal waters should ever be permitted, or in other words, that nothing should ever be done to diminish the amount of tidal water flowing up and down a channel. This principle has eminent supporters, but it will be seen that a strict adherence to it would debar us from erecting any such structures as dikes or moles, which displace a considerable volume.

Probably a more nearly correct statement of the requirement would be that *no structure should be permitted, which creates injurious modifications of the currents.* For instance, where a current is sufficient to maintain a channel, no obstruction should be placed across its path, as otherwise the velocity will be reduced, and a bar or shoal will inevitably be formed. The problem before the

commission for the building of this harbor, was then, *how to protect vessels from the winds, waves and ice, without interfering with the currents.* As the winds and waves generally came from one quarter, and the ice and currents from another, it was apparently separated into these two factors, and the result was the two isolated barriers.

Unfortunately the ice and the currents follow nearly the same path, and it does not appear to have occured to the projectors of the harbor that, in opposing the first by the means proposed, they were also seriously modifying the second, or, if it did, they certainly did not provide a separate treatment, or one which should check and break up the ice floes, while it permitted the currents to pass with but little restraint.

As floating ice is restricted to the surface, it should be resisted at or near that plane by floating, metallic caissons, moored to the bottom, so as to furnish ample water-way beneath, and so avoid the formation of the otherwise inevitable bars in the harbor, due to a reduction of velocity.

Recognizing these requirements, Col. Henry M. Robert, U. S. E., now in charge of this district, has recently proposed such caissons for the ice harbors on the Delaware, near Reedy Island.

The principal defect then in the plan of the Breakwater Harbor consisted in placing the ice-breaker athwart the currents, and so inducing an extensive and protracted shoaling of the harbor. The manifest remedy for this defect is to take it away, and to substitute for it floating ice-breakers.

The breakwater, having been placed more nearly in the direction of the ebb and flood, has not so seriously modified the currents, but we think it would have been an improvement, had its axis been thrown around nearer to the N. and S. line, and the whole structure been then moved to eastward, still keeping the axis inside the cape, and parallel to the existing currents.

The Gap.

From the careful surveys made in 1879, under the direction of Col. Wm. Ludlow, U. S. E., it appears that at the gap there are strong currents both at flood and ebb, and an examination of the velocity curves shows the *flood* currents throughout this section

to preponderate over the ebb. The greatest scour in the entire harbor is found to be during the last two quarters of the flood tide, as it runs into the gap past the N. W. end of the breakwater. The result is a hole on the outside, just under the end of the breakwater, reaching at one time to 50 ft. in depth, and a bar on the inside, with only 11 ft. of water.

(The plane, upon which the breakwater rested, extended originally from 31 ft. at the S. E. to about 27 ft. at the N. W. end.)

If there were an *ebb* scour at the gap, then the material carried through it would be precipitated just outside, in consequence of the retardation produced by expansion of currents and dissipation of energy; but no such crest can be found. On the contrary, the ground appears to fall away from a point inside, uniformly to the main channel. At the east end of the ice-breaker is found another 50 ft. hole, most of the material from which has gone to the bar, extending from the middle of this barrier to the 11-ft. spot near the N. W. corner of the breakwater. We see, therefore, without further elaboration, that this gap is an injury to the harbor from the fact that it enables the *flood* tide to carry sediment in, and that the resultant of these forces is opposed to that of the ebb entering below the west flank of the ice-breaker, and forming the neutral ground along which occurs the crest of this inner bar.

The gap should, by all means, be closed therefore, not simply "to prevent the ebb from escaping," but for the more important reason of preventing the flood from entering, and thus to cut off this source of opposition and sediment. This excess of flood over ebb is caused chiefly by the projection of the eastern end of the ice-breaker beyond the line of the breakwater, thus catching the flood and turning it into the gap.

But to close the gap and leave the ice-breaker, would merely create a slackwater pool in the angle, which would soon silt up, creating a bar extending from the west end of the ice-breaker to below the middle point of the breakwater. This would ultimately become an island—and the waterway to the westward would gradually be deepened by the prevailing ebb scour, as shown by the velocity curves from stations (8) to (12), as well as by those inside the harbor at stations (13), (14) and (15).

Since, however, the gap should be closed and the ice-breaker razed, the proper move would be to turn the ice-breaker into the gap, by taking the material already at hand and dumping it into the opening. This would cost less and be more effective than any other plan, by letting in more of the ebb and keeping out part of the flood. In fact the breakwater and the shore would then form converging jetties, and thus produce a scour which would go far towards deepening the harbor.

That there can be no doubt of this result will be shown by a critical study of the eastern outlet, which we will designate as

The Gorge.

It is the section lying between the eastern end of the breakwater and the shore. The distance is half a mile and the area 57,868 sq. ft. The hydraulic mean radius is 20.96 ft. The shore and breakwater make with each other an angle of 45°, forming, with the gap closed, a funnel of about 6,000 ft. in depth to THE BASE, or rear section, where the distance across is about 7,200 ft., mean depth, 15.08—and area 108,900 sq. ft.

The ratio of the area of the Base to that of the Gorge, is therefore as 1.88 to 1, and if the same volumes were to pass through these sections in the same times, their velocities must vary inversely as the area, and hence the greater scour at the Gorge.

These quantities as well as those for the Gap are better expressed in the following form:

Relation of Quantities at the Gap, the Gorge and the Base.

Location.	Area.	Hyd. Mean Depth.
The Gap,	40,040 sq. ft.	28.57 ft.
The Gorge.	57,868 "	20.96 "
The Base.	108,900 "	15.08 "

Assuming the gap to be closed, the surface area of this part of the harbor will be about 32,000,000 sq. ft., or 1.15 sq. miles.

Taking the mean rise and fall of tide at 4.3 ft., the volume of water passing out at the ebb tide, of 5h. 59m. duration, say 6h., would be 382,222 cub. ft. per minute. This is independent of the

volume entering the basin at the base and going out through the gorge during this same interval.

In its course to the sea, the ebb tide is deflected by the converging lines towards the gorge, and forms two currents, one near the shore, where the frictional resistance is greater, the path longer, and the depth lesser than in the other channel, skirting the inner edge of the breakwater. In consequence, two valleys are formed, one parallel to the shore, the other near the jetty, with a low, flat spur between them. The stronger of these currents has scoured out a basin inside the section of "the Gorge," extending to a depth of 54 ft., and containing about 286,250 cub. yds. below the 30-foot curve. This contour, which originally passed near the eastern end of the breakwater, has been cut back a distance of 900 ft., and has a channel of 600 ft. between its opposite branches. The area covered by the 30-foot plane inside the gorge is 18 acres. Here then is an instance of a jetty placed in the open sea scouring out and maintaining a channel of over 30 ft. in depth, and for a distance of more than 3,000 ft. It will also be observed that the eddies formed by the currents passing the ends of the jetties have scoured to depths of between 50 and 54 ft. The hole in New York harbor which we attributed to eddy action is 52 ft. This would seem, then, to be the limit of such scour under these conditions of velocity and contraction. It may also be laid down as a law that the deep holes are on the up stream side of a gorge or contraction, that is, the side toward the current and the bar or crest is below. This indicates the direction of bottom movements. Thus the hole on the south side of the ice-breaker, near the western end, has been made by the flood or up stream current, and an inspection of the velocity curves at station (7) shows this supposition to be correct, for the flood is the stronger at that station.

It will be seen from the above that the deep water at "the Gorge," is attributed not to the "inrush of the flood," as has been alleged to be the case, but to the reverse currents, and this view is verified by the velocity curves at stations 1, 2 and 3, where the ebb predominates; it is further confirmed by the low crest formed outside the section and by the lump on the outer side of the eastern end of the breakwater. Instead, therefore, of material being carried into the harbor through this section, it is scoured out.

Enclosing the Harbor.

With reference to the plan of enclosing the harbor at its upper end for the purpose of keeping out sediment, it will be seen that a structure which would shut out sand must also exclude the currents which carry it, and will therefore destroy the only natural force that can be utilized for removing the present extensive deposits. It would equalize the ebb flow, and so neutralize the existing ebb resultants, which can be employed for the purpose of deepening the harbor.

If such an enclosing jetty were to be built out from the shore gradually, it would produce a scour in the portion of the section remaining open, making along the line of the work, deeper water, and so increasing the cost of construction; and the material scoured from this line would be left inside, only to be removed by dredging. Upon completion of the enclosure, the ebb resultant being cut off, the flood and ebb at the gorge would be about equal, and no material could be carried out; but whatever was carried in by winds or waves, would remain unless removed by artificial means. The cost of the enclosure is estimated at $1,500,000; but this does not include the dredging of the harbor, nor closure of the gap, which latter is placed at $500,000 more, making a total of $2,000,000, exclusive of the dredging.

The Remedy Proposed,

therefore, which seems best adapted to the exigencies of this case, appears to be the transfer of enough of the present ice-breaker to the gorge to fill it (80,000 cub. yds.), and to substitute therefor, iron caissons or booms as a protection from ice. This would open the harbor to the action of the ebb scour, which could be materially assisted by properly angulated, temporary or floating jetties and deflectors. The time required to effect these changes, if vigorously prosecuted, would be much less than the four years estimated to be necessary to close the gap by the present plan.

The Estimate

in the Report of the Board of Engineers, as submitted in 1879, calls for

"50,000 cub. yards of rip-rap stone, @ $3.00, . .	$150,000
25,000 " " " dimension stone, @ $18.00, .	450,000
	$600,000"

and it adds:

"The plan of construction being to build up from the bottom with rip-rap stone to 12 ft. below low tide; then to 12 ft. above low tide, a wall with say 30 ft. base and 12 ft. thickness at top with very large quarried dimension stone or with concrete."

The breadth of the substructure at top is subsequently fixed at 48 ft. The average depth is 30 ft.,* which leaves 18 ft. below the 12-ft. plane, and the average length at this depth is at least 1200 ft. Taking the side slopes at 1 on 2 = $\frac{1}{2}$, there would result for the volume of rip-rap, 67,200 cub. yds., instead of 50,000, and for the prism of concrete or masonry, $24' \times 21' \times 1390'$† = 25,946 cub. yds., instead of 25,000, with no allowance for shrinkage or settlement. This would make the aggregate cost at the figures given in the estimate $668,638, and the volume, 93,146 cub. yds.

To close the gap by a triangular mole, having side slopes of $\frac{1}{2}$ and reaching to the surface, would require a volume of only about 80,000 cub. yds. of stone. The form of the structure, having a re-entrant angle, would cause a bar to form outside, and so reinforce the breakwater. By taking the material from the ice-breaker for filling the gap, we "kill two birds with one stone," for the subsequent expense of removing, the ice-breaker is saved, and we have no doubt as to the desirability and ultimate necessity of its removal. To remove it and carry the material ashore, or otherwise dispose of it, would cost about $300,000, so that the plan proposed would save about $500,000, and give much deeper water without dredging. This leaves an ample margin for floating ice-breakers should they be found necessary.

In Conclusion,

we have merely to add that, after much discussion, an Act of Congress was passed August 2d, 1882, making an appropriation of

* Col. Ludlow gives the average depth at 31 ft. Page 462, 1879. We are therefore on the safe side.

† Length at low water line. Report, 1885, page 846.

$125,000 to commence the work of closing the gap, and although it was begun at an early date thereafter, yet in consequence of frequent changes of executive officers,* and modifications in plans, so much time has been lost, that at the date of the Annual Report of Capt. Heuer, June 30th, 1885, there had been completed the construction, and placing of 258 mattresses (30′ × 16′ × 2′) in a layer, 90 ft. wide along the gap, and the "loading of the same with 1813 cub. yds. of small stone, and 1198 tons of large stone." This is equivalent to about 2412 cub. yds. A contract was then being executed for 23,000 tons, or about 13,000 cub. yds. of stone by Andrews & Locke, of Baltimore. The total amount expended was:

To June 30th, 1884, ...	$26,246 95
" " " 1885, ...	29,113 52
	$55,360 47

(The total estimate under Genl. G. Weitzel, U. S. E., was $675,000.) The amount expended represents the cost of the mattresses, piles and plant, with the 2412 cub. yds. of stone in place. The volume of the mattresses is about 9000 yards. This, with the stone in place, will be about 11,500 cub. yds., or about 11 per cent., which, at the same rates, would make the cost about $503,300, and the time to close the gap, about 22 to 25 years.

The total expenditures from 1829 to June 30th, 1885, have been $2,422,195.27, and the harbor is almost useless for large draught vessels. The proposed expenditure of another half million to close the gap will produce but small results, so long as the ice-breaker remains in its present position, and we are of the impression that the benefits to the harbor would be more than doubled at half the cost by the plan we have suggested.

Government Appropriations.

This leads us to make a note upon the present method of doling out the government appropriations piecemeal for every creek, river, pond, lake, or harbor, which may be considered worthy of attention.

* There have been four changes in as many years.

It is not possible for the Government or any engineers to do economical or effective work, when their resources are thus restricted, and still more, it is an unnecessary burden upon the Members of Congress, who, in addition to their multifarious duties, are required to vote upon the multitude of items entering into the River and Harbor bill.

It is impossible for our representatives to inform themselves as to the requirements of each individual case, for which they may be asked to appropriate an amount varying from a few dollars to hundreds of thousands. Again since the appropriations are made annually, and it is unknown whether or not the bill will pass for the next year, the estimates submitted must contain a large contingent to provide for maintenance of plant and work in case of failure. Such failures to pass the bill, since the war, have occurred in the years '64, '65, '77, '83, '85. The U. S. Corps of Engineers must not be held responsible for the wastefulness incident to the existing methods of conducting our public works, as they are in no sense accountable for the irregularity of the appropriations or for the frequent changes of stations and duties, which prevents a personal study of the numerous and difficult problems submitted, often for their immediate action.

It would undoubtedly be more satisfactory to all interests to make an appropriation in a lump sum, and to place it in the hands of a Commission, to be apportioned to the three or more grand geographical divisions into which this country is naturally separated by the Alleghany and Rocky Mountain divides and the basin of the Great Lakes. Thus, by grouping according to topographical features, into basins of greater and lesser magnitude, with a local officer or engineer permanently attached to each, the very best results could be obtained, and a judicious application be made of the money appropriated for any section of any department; the time of Congress would be greatly relieved for the more legitimate work of legislation, and the rapidity of execution of the public works be greatly promoted.

XXII.

SOME ENGINEERING FEATURES OF THE NICARAGUA SHIP CANAL.

By J. Foster Crowell, Active Member of the Club.

Read February 20th, 1886.

At the last Meeting of the Club the writer presented a general chronicle of what has been accomplished towards each of the three projects for establishing Interoceanic Communication, and a comparison of their ultimate utility, assuming for the time being that the Engineering problems for all had been solved, each in its place.

For that presentation it was not essential to enlarge on the characteristics of the Panama Canal, which will, if completed, be a thorough cut at the sea level; nor upon those of the Ship Railway, which, *per se*, is to be continuous from ocean level to ocean level, so far as we are informed by its designers—for although it is claimed by others that in order to reach the termini of the rails, canalization may have to be resorted to, such considerations were foreign to the purpose of the paper.

But to arrive at a proper understanding of the Nicaragua scheme, in its modified form, it became necessary to briefly describe its composite character and its component parts. The scope and limit of the paper, however, did not permit of detail, and it is in response to the request of some members who were present at that meeting, for fuller information, that the writer has agreed to supply it, in as far as he is able.

Speaking to Engineers, and with a high sense of the demands of professional courtesy, he deems it proper to preface this duty with such a clear explanation of his attitude in it, that no misconstruction can be possible. He desires to state, first, that he has no interest, other than the professional one we all have, in this undertaking, and in no sense is commissioned to be its spokesman; second, that his labors in connection with the original surveys, prior to 1874, have given him familiarity with this region, in which he spent the larger parts of two years of active

work; third, that the paper above referred to was written and read without the knowledge of the distinguished engineer whose plans are to be discussed; and, fourth, that since the last meeting the latter has been furnished by the writer with an abstract of the paper, and made acquainted with the desire of our Members to know more of the subject, and he has kindly furnished, in response, the drawings which will presently be presented to your notice.

In proceeding to the discussion it may be well to remark, that in the limited sense in which the word canal is generally used, it is a misnomer for the Nicaraguan project, which is a slack water system of grand dimensions, wherein lake and river navigation, practically unrestricted, constitute $129\frac{8}{10}$ miles, or 77 per cent. of the entire passage between the oceans, while the artificial channels aggregate only 40 miles, or 23 per cent., the entire transit being $169\frac{8}{10}$ miles. Of these artificial channels, more than 13 miles will be of such depth and width as to deprive them of any objectionable restriction, leaving only an aggregate length of 27 miles, divided into several separate stretches, of confined canal.

To grasp the problem firmly in our minds, we must recur to the topographical features of the site. The Lake of Nicaragua, about 90 miles long, by from 35 to 45 miles in width, receives the surface drainage of a basin that contains about three times its superficial area, or about 8,000 square miles. The strip of land that separates the Lake from the Pacific Ocean is, at its narrowest places, from 12 to 15 miles in width; at a point near where the width is least, the mountain range which forms the back-bone of the entire Isthmus, has its lowest notch, and at this point is the location for the western section of the Canal: this mountain range heads the drainage into the lake on the west and south. On the north and east are other ranges which intersect each other. At the north-western end of the Lake enters a short river, the Tipitapa, which is, in the rainy season, an overflow outlet for the waters of Lake Managua, whose lowest level is 15 feet higher than the highest level of Lake Nicaragua, which is 110 feet above ocean mean tide. The drainage of this great basin flows into the lake in numerous small rivers. The only break in the mountains bordering the basin on the south, north and east, is at the extreme

eastern end of the lake, and through it the San Juan River flows towards the Atlantic—the only outlet that the lake has. The San Juan Valley is a narrow prolongation of the basin, being hemmed in on both sides by extensions of the mountains, as far down as the mouth of the San Carlos River, about 64 miles from the lake, which enters from the south through a lateral valley of the same general character.

A short distance below the mouth of the San Carlos, at Ochoa, the main valley narrows, and here the dam which is to establish the summit level is to be placed.

With the single exception of the San Carlos, all the tributaries of the San Juan, from the Lake to Ochoa, are small streams with rapid fall from the near-by mountains; valuable as feeders in the aggregate, and possessing no injurious qualities affecting the scheme. None of these streams are silt-bearers to any appreciable extent; a fact that is clearly demonstrated by the character of a remarkable stretch of dead water in the San Juan—the Agua Muerte—which, although forming a subsiding reservoir, 20 miles in length, practically without current, has preserved its unusual depth, ranging from 20 to 60 feet, and clear bottom throughout the ages.

The lower San Juan, that is below Ochoa, need not occupy our attention at this time, for it forms no part of the scheme of navigation.

Just above Ochoa, a small stream, the Machado, enters from the north, and a short distance up its valley a cross valley enters from the east, the latter being nearly parallel to the San Juan, and separated from it by the spur in which is rooted the northern end of the dam: the raising of the water by the dam floods this cross valley, and converts it into a natural canal for some distance towards the Atlantic.

Nine miles below the dam, another river, the San Francisco, enters the San Juan from the north, being formed of two branches, which unite just above the mouth, these branches are also nearly parallel to the San Juan, one stretching back towards the Machado, and the other, the Caño de los Chanchos, towards the north-east. Across the river, between the forks and the San Juan, a second dam, the same height as the Ochoa Dam, is to be thrown,

and the divide between the Machado and the San Francisco will be passed by a stretch of canal. By this treatment the summit level is prolonged up the Caño de los Chanchos, and carried through the divide between the San Francisco and San Juanillo Basins, and enters the valley of the Deseado, a stream flowing into the San Juanillo, follows its bed a short distance, then takes its left bank and reaches the site of the upper lock on the Atlantic side of the lake, the length of the cut through the divide being 14,200 feet, with an average depth of cutting of 147 feet above the bottom of canal, constituting the heaviest work on the entire line. This lock (No. 3), carved in a rocky spur of the northern hills, is the eastern end of the summit level, which stretches back through the San Francisco Basin, up the San Juan, and across the lake to the first lock on the west side, a distance of $144\frac{8}{10}$ miles.

This rock-hewn lock drops the canal 53 feet, into the valley of the Deseado: 4,600 feet further is another lock, with a drop of 27 feet, and thence the line follows the widening valley 1,500 feet further, to the third and last lock, which, with a drop of 26 feet, lowers the canal to the sea level. From this lock to Greytown harbor, a distance of 61,000 feet, $11\frac{6}{10}$ miles, the course is direct across the low, flat basin of the sinuous San Juanillo and through the lagoon district, the average of which is 10 feet above tide.

Waste weirs are to be provided for the control and discharge of the surplus water of the San Francisco. The inextensive surface drainage of the Deseado, the San Juanillo and the Laguna Bernard, is to be kept from the canal by suitable artificial channels, and through the low lands the canal will be further protected by embankment.

On the western side of the lake the summit level is carried through the divide.

The following description of the western division and lake section is from a recently published article in the *American Engineer:*

Leaving the western shore of the lake at the mouth of the River Lajas, the line of the canal follows the bed of that stream, which is to be diverted into the lake at another point, for one and a half miles, crosses a little plain three quarters of a mile wide, enters the valley of the Guscoyol, a small tributary of the Lajas, follows this to the summit, 4.7 miles from the lake and 41.41 feet above it, then descends one and three-

quarter miles over a moderately rolling country to the Rio Grande, a large stream draining an extensive area of the eastern slope of the Cordillera. This stream is also to be diverted into the lake by an artificial channel across the ridge, and the canal, following its upper valley for about one and a half miles, reaches the head of the broad lower valley and the first of the locks. At this point the summit level ends, and from here the canal sweeps down the broad valley of the Rio Grande, dropping by three more locks of 26.4 feet to 29.7 feet lift, to the sea level at lock No. 7, 1.4 miles inland from Brito. Here the canal practically ends, as from this point to the sea it is so enlarged as to form an extension of the harbor.

Between the lake and Brito one small stream is taken into the canal by a receiving weir, the River Tola, and several small streams coming from the north are to be passed under the canal, and along its lower portion will be ditches to intercept the surface drainage and convey it to the sea.

The material to be excavated in this division is sand, clay, gravel, and in the divide cut, rock, which will be utilized in the construction of the breakwater at Brito, pitching the canal slopes, and in the concrete for the locks, culverts, weirs, and the dam across the Rio Grande. The location of the canal in this division is the same as that proposed by Civil Engineer Menocal on his return from Nicaragua in 1880. The prism, however, has been increased, the number of locks reduced, and their location changed. The enlargement of the terminal section is also a new feature.

The lake; 56.50 miles from the mouth of the River Lajas to Ft. San Carlos at the head of the San Juan. Through this section no less than 28 feet of water can be carried now to within 2400 feet of the mouth of the Lajas on the west shore of the lake, and within eight miles of Ft. San Carlos on the southeastern shore. For the former distance some dredging and rock excavation under water is necessary, and in the latter, dredging in soft mud to an average depth of 3½ feet to extend deep water from mouth of Lajas to entrance of San Juan. These dredged channels will be 150 feet wide on the bottom. For a distance of 24 miles between the Lake and Toro Rapids, there will be needed some dredging to secure a bottom with 150 ft. in the San Juan.

With this description and a glance at the profiles and maps before you, the general scheme must be clearly understood, and we may therefore turn to the examination of the drawings of the structural parts of the scheme, and describe in order,

1st. The Dams.

2d. The Locks, exemplified by

a. The tidal Lock at Brito Basin.

b. The great rock-hewn Lock, No. 3.

c. The Rolling Gate, designed by Mr. Peary for this particular case.

3d. The Brito Basin.

4th. The Harbor at Greytown.

The Dams.

The two dams at Ochoa and San Francisco, although they are to hold in place the far-reaching waters of the grand summit level, are so favorably located that their construction presents no unusual difficulties.

The first is to be rooted between two steep, rocky hills, at a point where the river is 1,133 feet wide, with an average depth of $6\frac{6}{10}$ ft. It will be 1,255 ft. long, 52 ft. high above present water level, with foundations extending 20 ft. below. Constructed entirely of concrete, with timber lined crest, front and apron, and rip-rap protected back, it forms a gigantic monolith, wedged between the rock abutments of the everlasting hills.

The other will be 6,500 ft. long, with a maximum height of 51 ft. It will consist of an embankment. Near the embankment a waste weir 1,000 ft. long will be cut through the adjoining hill, to control or discharge surplus water, and there will also be a tunnel or culvert cut through the solid rock and controlled by gates, to be used in emergencies, to draw off the water of the San Francisco.

The Locks.

The locks proposed are magnificent structures, 650 ft. long between gates, 65 ft. wide between gate abutments, and with 29 ft. of water over the sills, capable of containing the "City of Rome," or the "Acapulco" and "Colon" together. There are seven (7) in all; five with lifts varying from 26 ft. to 29.7 ft.; one (the tidal lock at Brito) with a variable litt, 24.2 ft. to 33.18 ft., dependent upon the stage of the tide; and one, lock No. 3, at the eastern extremity of the summit level, having a lift of 53 ft. This lock will be carved from the solid rock and faced up with concrete. The other locks will be built entirely of concrete, on a concrete, or concrete and timber foundation, as may be required, and all will be lined with heavy timber from the top of the walls to 15 ft. below the lower water level. Fender cribs or piles, dependent on material of bottom, protect and guide entering vessels and floating moorings in the lock chamber, rise or fall with the vessel, keeping her steadily in the axis of the lock. Two 10-ft. culverts, extending along the sides of the lock, and connected with it by 22 branch conduits, fill or empty the chamber in 15 minutes for lock No. 3, and 11 minutes for the others.

All the head gates, and the tail gates of all the locks, except No. 3, are iron sliding gates, retreating into a lateral recess when opened. For the tail gate of lock No. 3, 88 ft. in height, there has been adopted a rolling gate of novel design, proposed by Civil Engineer R. E. Peary, U. S. N, which meets all the requirements of the problem, and which may be eventually adopted for all the other locks. This device consists of an iron rolling or tumbling gate, traveling on rails, and retreating when open

into a lateral recess. It is manipulated by a small car traveling on the top of the lock, and connected to the gate by a long strut or pitman rod.

In shape the gate may be described as a rectangular upper portion, resting on a curved lower portion, the inner or rear part of the curve being a quadrant of a circle of such radius that the length of the arc of the quadrant is equal to the width of the lock.

In the lower portion of the gate is a water-tight compartment, extending up its inner rear side to the top, to contain a shifting water ballast. The remainder of the gate consists of open trusses plated on the down stream chords. Flanges upon the curved bottom of the gate prevent any lateral movement, and any possibility of slip forward or backward is precluded by four chains, each equal in length to the arc of the rolling quadrant, arranged in pairs. One pair is attached at one end to the gate at the upper extremity of the quadrant, and at the other end to the bottom of the lock directly under the lower extremity of the quadrant; and the other pair is attached in just the reverse manner, the motion of the gate either forward or back, winding one pair upon the periphery of the rolling quadrant at the same speed that it unwinds the other pair, thus rendering it impossible for the slightest slip to occur, while at the same time the utmost freedom of rotation is permitted.

The car is a rigid rectangular frame traveling on two rails placed at right angles to the axis of the lock, one on each side of the gate recess. From the forward end of the car to the upper front corner of the gate extends an iron spar, attached both to the car and the gate by pin joints, permitting free motion in a vertical plane, but kept rigid and unyielding in the horizontal plane by wire rope guys, reaching from its outer extremity to the sides of the car.

Motion is imparted to this car by a compressed air or hydraulic motor situated on the car, which drives a shaft bearing two drums. Each of these drums carrying several turns of a fixed cable, the car is worked backward and forward by simply reserving the motion of the drums. By means of water ballast, the gate can be adjusted to exert any desired pressure on the rails.

The method of preventing any lateral movement of the bottom of the gate has already been noted. Lateral motion or deflection of the top by the action of the wind is prevented in two ways, viz.: by rollers on the opposite faces of the gate recess, and by rigid (laterally) braced connecting rod above mentioned, by which the gate is adjusted and supported precisely in its vertical plane of motion.

To close or open the gate, the car is started, the upper front corner of the gate rises, and moves forward or backward in response to the push or pull of the connecting rod; one pair of chains unwinds from the gate while the other winds on it; the water ballast shifts with the gate, neither assisting or retarding its motion, but simply keeping it on the rails, and thus under perfect control, and held as in a vise in every direction, the gate rapidly and smoothly advances from or retreats into the recess.

The advantages of this gate are perfect control, combined with rapidity and simplicity of operation; most advantageous application of power; concentration of all moving mechanism on top of the lock, where it is perfectly accessible; and facility of access to all but a very small portion of the gate itself for painting or repairs, without interfering with the use of the lock.

The necessary machinery for operating the locks and culvert gates, hauling vessels in and out of the locks, electric lighting and other purposes, will be worked by hydraulic power.

The Harbors.

We have before us the Hydrographic maps of the conditions of the two sea termini at Brito (in 1872–3), and at Greytown, in '72, '73, '74 and 1880, which will serve to illustrate the methods proposed for protecting the entrances to the canal. It must be borne in mind that for all the purposes of through commerce, the Lake of Nicaragua forms the most superb harbor that can be imagined: for refitting, taking in stores, docking for repairs, and all the multifarious needs of shipping, nothing more could be asked for. Situated in a magnificent and healthy country, with immunity from continued gales and ample shelter, this beautiful inland sea is ready and waiting this its most appropriate use.

What is required then, at either ocean, is not a harbor for retaining vessels, but simply adequate protection to the canal entrance and sufficient water to reach it. It is unnecessary to do more than this, inasmuch as the parts of the canal which are at sea level, are to be made sufficiently wide to accommodate vessels awaiting lockage up, without interference with the passage by others.

The charts show the means proposed to secure adequate protection and sufficient water; and with them before you it is not necessary to say anything more in order to expel the bugbear which has always been set up by the enemies to this project.

No changes are proposed in the methods recommended in Captain Lull's report of surveys in 1872–3 for the improvement of the harbors at the termini of the canal. But the change of location of the tidal lock at Brito, from the inner end of the harbor, as was before proposed, to a place 1.4 miles inland, necessitates material modifications in the anchorage. The canal is to be so enlarged along that portion from the lock to the harbor that it will be practically an extension of the harbor, where vessels can either lie or pass each other without inconvenience.

A large harbor for the sole purpose of accommodating a number of ships, is therefore, unnecessary with the new plan; the main object being to have an easy entrance to the harbor, and a sufficient area inside to permit the expansion and ultimate destruction of the swell before reaching the lock. This will be effectively accomplished by the plan proposed.

There is no marked change in the conditions of Greytown Harbor since the United States Government survey of 1872–73, except an increased silting up of the inner bay, and a slight recession of the six fathom line off shore.

The plan of improvement is the same as before recommended, and is capable of much greater facility and economy of execution, owing to the abundant supply of

stone to be obtained from the neighboring cut through the divide, instead of from Monkey Point, as before proposed. That portion of the canal from the last lock to the sea will be enlarged, as at Brito, to form an extension of the harbor, except that here the enlargement extends 11.6 miles, as against 1.4 at Brito.

Having described the note-worthy permanent structures which the Engineer proposes, we find that they are, all told, eleven in number, viz.: two dams, seven locks; one jetty, at Greytown; and one break-water, at Brito, which latter may possibly be dispensed with.

In addition to these, there will be the receiving and waste weirs and the culverts for passing the waters of the Tola and smaller streams under the canal, which have already been enumerated.

As to the resources of the country for the necessary material required in their construction, the following statement of Mr. Menocal is quoted:

Materials of Construction.

On the western side of the lake a great variety of excellent construction timber abounds on the line of the canal, and for many miles to the north and south, its present market value but slightly exceeding the cost of cutting. In fact, it may be safely said that in clearing for the canal more timber will be obtained than will be needed for the work. The valley of the San Juan River from Toro Rapids to the San Juanillo, including the valley of the San Francisco, is also heavily timbered; the virgin forests having never been disturbed by the hand of man, except on the immediate river banks, where a few wood choppers keep the river boats supplied with fuel. Much of this timber compares favorably in the most important characteristics with the best in the markets of the world, and its durability, both when exposed to the weather and when under ground or in the water, has been fully demonstrated by its extensive and varied use in that country for many years. From Greytown to Lock No. 1 (some 12 miles), heavy timber is also found on the line of the canal, but of an inferior quality to that of the interior. However, for temporary structures it would answer as well.

No large quarries have been opened in Nicaragua, and with the exception of a limited number of coarse sandstone blocks used in the construction of some public buildings, dimension stones are rarely used. Rubble masonry is adopted where something neater and more substantial than adobe is desired, while bricks are seldom seen except in floors. A superior quality of lime, as evidenced by the existence to-day in an almost perfect state of preservation of indigo vats and dams over a hundred years old, can be had at several places close to the line of the canal, and when properly manufactured there is no question but that it will prove equal if not superior to many cements in the market.

It is believed that large blocks of granite could be obtained from the east shore of the lake, but it is not proposed to use any for the purposes of the canal. Concrete is the most suitable material for the construction of the locks and dam, and the best stone

for this purpose (hard trap) is found on the line of the canal, and its cost will be only that of transportation from the excavations through the divides.

The best of clean sand and gravel abounds on the shores of the lake, in the bed of the Rio Grande in the Western Division, and in the River San Juan, from the mouth of the San Carlos to Greytown; while suitable clay for the manufacture of bricks is met with at numerous points along the route.

Dimensions and Capacity.

In estimating the capacity of the Nicaragua Canal, a comparison of its proposed dimensions with those of the Suez Canal, and a knowledge of the time of transit and tonnage which can pass through the latter daily, will assist us to a correct conclusion. It has been found that the Suez Canal is unable to accommodate a traffic of more than 6,000,000 tons per year without serious delays to navigation, owing to its dimensions and insufficient number of turnouts. In the Nicaragua project not only have enlarged prisms been estimated for, but large basins have been provided at the extremities of each lock, where vessels can wait or pass each other without delay. These basins, the enlargement of the sea-sections, with the lake, the river, and San Francisco Basin, will permit vessels to pass without delay at almost any point on the route. There are only $12\frac{6}{10}$ miles where the canal prism itself is not sufficiently large for vessels to pass, and this distance is not continuous, but so subdivided that the largest continuous section is but $3\frac{67}{100}$ miles, and with but two exceptions (the cuts through the eastern and western divides) these short reaches of confined canal are situated between the lock basins, and can be traversed by any vessel in less time than is required for lockage, and so will not be a cause of delay.

As will be seen from the following table, the bottom width and the depth are larger throughout than in the Suez Canal, as now constructed.

In addition to the increased dimensions, provision has been made for lighting the entire route, so as to permit uninterrupted navigation day and night, and thus nearly doubling the capacity, the superabundance of water power, available at all parts, rendering the use of electricity on a grand scale for this purpose entirely feasible at a minimum cost.

Table of Comparative Dimensions.

	Nicaragua Canal.		Suez Canal.	
	Bottom Width.	Surface Width.	Bottom Width.	Surface Width.
Rock Cuts,	80 ft.	80 ft.		
Earth Cuts,	80 ft.	184 ft.	72 ft.	190 ft.
Terminal Cuts,	120 ft.	288 ft. / 342 ft.	72 ft.	330 ft.
Dredged Channel (in San Juan),	125 ft.	1000 ft. to 2000 ft.		
Dredged Channel (in lake),	150 ft.	35 miles.	72 ft.	330 ft.
Basins,	150 ft.	210 ft.	72 ft.	330 ft.
Depth of Water,	28 and 30 feet.		26 feet.	

Estimated Time of Through Transit.

In the lake and the larger portion of the San Juan River vessels can travel as fast as at sea. In some sections of the river, and possibly in the San Francisco Basin, although the channel is at all points deep and of considerable width, the speed may be somewhat checked by curves.

In the Suez Canal the maximum speed of all vessels is fixed at 10 Kilometers ($5\frac{1}{3}$ nautical miles, or $6\frac{1}{10}$ statute miles) per hour. During the year 1883, 3307 vessels with a mean gross tonnage of 2435 tons, and a mean net tonnage of 1747 tons, passed through the canal, the mean average effective sailing time being $19\frac{1}{2}$ hours, or $5\frac{1}{10}$ nautical miles per hour.* These facts show conclusively that vessels of 4400 tons, 400 feet long, 52 feet beam and 22 feet draught, can go through the Suez Canal at an average speed of six statute miles per hour, and smaller ones at 6 to 8 miles per hour, and the experience shows that the actual time of transit is not likely to exceed these figures.

* The United States steamship "Tennessee" went through the canal in 1875, averaging 5.3 knots (6.1 miles).

The United States steamship "Swatara" made 5 to $5\frac{1}{3}$ knots (5.76–6.61 miles). The English troop ships, 4400 tons, 400 feet long, 52 feet beam and 22 feet draught, make about 5 knots (the average effective sailing time for 49 voyages being 17 hours). The United States steamship "Marion" went through last May, making 7 to 9 knots.

With this reliable data the probable time required for the transit at Nicaragua can be closely approximated, and it will be seen that the following estimate, made by Mr. Menocal, is within safe limits.

Estimated Time.

	Miles.		H. M.
In Canal proper (canal and basins, east side of lake, 22.44 miles, west side, 16.54 miles), . .	38.98	at 5 miles pr. hour,	7.48
In San Francisco Basin, . .	8.51	" 7 " " "	1.14
" San Juan River, . . .	64.54	" 8 " " "	8.04
" Lake Nicaragua, . . .	56.50	" 10 " " "	5.39
Seven locks (45 minutes each), .	1.27		5.15
Possible detentions in narrow cuts,	. . . .		2.00
Total distance, . .	169.8	Total time,	30.00

On the above basis of 45 minutes for lockage, and allowing but one vessel per lockage, 32 vessels can be passed per day, or 11,680 per year, which, with the average net tonnage at Suez, gives a yearly capacity of 20,000,000 tons.

As to the rain-fall, water supply and quantity required for lockage, there is fortunately not the slightest uncertainty, for, as will be seen from the following resumé, what is required is less than $\frac{1}{10}$ part of the mean flow or $\frac{1}{8}$ part of the minimum daily flow.

Water Supply.

Lake Nicaragua has a surface area of about 2,600 square miles, and a water shed of not less than 8,000 square miles.

Careful gauges of the San Juan River, at its lowest stage, between the lake and Toro Rapids, taken in 1873, showed a minimum flow of 11,390 cubic ft. per second. Colonel Childs estimated the discharge with full lake in the rainy season as 18,059 cubic ft. per second, which gives a mean flow of 14,724 cubic ft. per second, or 1,272,153,600 cubic ft. per day.

	Cubic feet.
Water required for one lockage, East side, ...	2,580,305
Water required for one lockage, West side, ...	1,465,944
Total, both sides, ...	4,046,249
	32
Water required for 32 double lockages per day, ...	129,479,968
Daily excess of lake supply, ...	1,142,673,632

To the latter amount is to be added the flow of the several tributaries of the San Juan River between the lake and the dam, and also the San Francisco and its tributaries, which will more than compensate for leakage and evaporation, though the latter need not be provided for, it being well known that in those latitudes the condensation during the night fully compensates for the evaporation during the day.

Estimates.

The estimate of cost of the canal has been prepared after careful computations of all the works required for its completion, with its accessories, from data obtained by an actual location. The prices which serve as a basis for the estimate, have been fixed with a thorough knowledge, and after careful weighing of all the drawbacks, disadvantages and tendency to increased cost incident to work in general in that region and their effect upon this work in particular, and it is confidently believed that with an able and intelligent management of the work they will, in every instance, be amply large.

Though the length of the line from sea to sea has been reduced 11.46 miles, the length of canal proper reduced, 21.44 miles, and the number of locks from twenty-one, as proposed by the United States Surveying Expedition of 1872–73, and eleven as proposed by Mr. Menocal, in 1880, to seven; the enlargement of the locks, and the prism of the canal, the change in the terminal sections, and the numerous improvements and additions, make the total cost nearly the same as that proposed in 1872–73. The constant object has been to provide for a canal which shall permit the passage of the largest ships now engaged in the commerce of the world, and a traffic of not less than 12,000,000 tons per year without restriction, rather than for the sake of economy in first cost propose what experience at Suez has proved to be inadequate.

A more detailed survey may show where changes in the details can be made in the interest of economy; but it is believed that the general location of the line cannot be greatly improved upon.

The work can be completed in six years, one of which would be spent in surveys and the necessary preparations for active operations.

Table of Prices.

Excavation in earth,	.40 per cubic yard.
Excavation in rock,	$1.50 per cubic yard.
Excavation in rock (sub-marine),	5.00 per cubic yard.
Dredging,	.20 and .40 per cubic yard.
Concrete,	$6.00 and $9.00 per cubic yard.
Stone pitching,	$2.00 per cubic yard.
Stone in breakwaters,	1.50 per cubic yard.
Puddle,	.75 per cubic yard.
Timber,	.50 per cubic foot.

Western Division:—

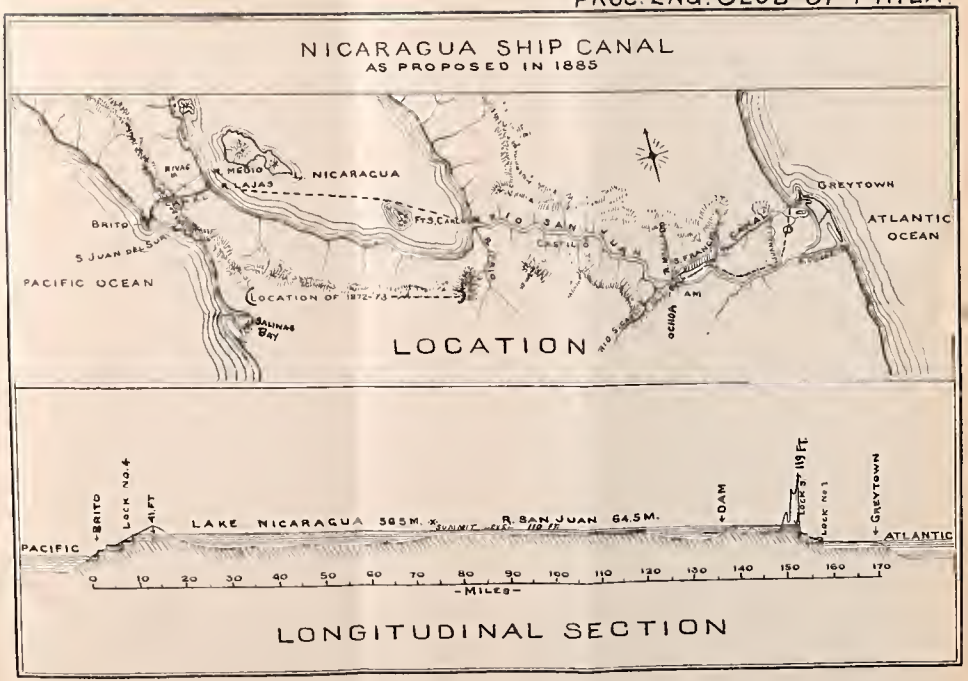
Excavation and embankment,	$ 8,486,292
Diversion of Rio Grande and Rio Lajas,	1,870,447
Other auxiliary work, including railroad,	753,329
Locks (four),	4,762,480
Harbor of Brito,	1,611,500
Total,	$17,484,048

Middle Division—	
Lake Nicaragua,	$ 379,520
River San Juan,	3,074,791
Valley of River San Francisco,	1,112,413
Dam across River San Juan,	1,858,975
Embankment across River San Francisco,	1,331,262
Embankment near Ochoa,	45,578
Railroad,	240,000
Total,	$ 8,042,539
Eastern Division:—	
The "Divide,"	$11,982,938
From the "Divide" to Greytown,	8,077,294
Locks (three),	3,561,515
Railroad,	320,000
Harbor of Greytown,	1,766,625
Total,	$25,708,372

RECAPITULATION.

Western division,	$17,484,048
Middle division,	8,042,539
Eastern division,	25,708,372
Total,	$51,234,959
Surveys, hospitals, shops, etc.; management and contingencies, 25 pr. cent.	12,808,740
Grand total,	$64,043,699
Estimated cost of canal, location of 1872–73 (25 per cent. for contingencies included),	65,722,147
Estimated cost of canal, location of 1885 on basis of prisms and prices adopted in 1872–73 (25 per cent. for contingencies included),	48,800,167
Difference in favor of present location,	$16,921,980

NOTE.—The estimates of cost and the detailed information printed in brevier are official, and are reprinted from an article in the American Engineer of November 26th, 1885.


NICARAGUA SHIP CANAL
AS PROPOSED IN 1885
RIVAS
R. MEDIO
L. NICARAGUA
LAJAS
BRITO
S. JUAN DEL SUR
PACIFIC OCEAN
LOCATION OF 1872-73
SALINAS BAY
FT. S. CARLOS
RIO SAN JUAN
CASTILLO
R. S. FRANCISCO
OCOTAL
DAM
GREYTOWN
ATLANTIC OCEAN
LOCATION
BRITO
LOCK NO. 4
41 FT
LAKE NICARAGUA 56.5 M.
SUMMIT EL. 110 FT.
R. SAN JUAN 64.5 M.
DAM
LOCK 37 119 FT.
LOCK No. 1
GREYTOWN
PACIFIC
ATLANTIC
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
MILES
LONGITUDINAL SECTION

XXIII.

A PRACTICAL TEST TO OPERATE A DISTANT SIGNAL BY A WIRE RUN THROUGH A PIPE FILLED WITH OIL.

By Wm. H. Dechant, Active Member of the Club.

Read March 6th, 1886.

During last September, a distant signal was required to protect a new crossing over the Little Schuylkill Branch of the Philadelphia & Reading R. R., between East Mahanoy Junction and Tamanend. The distance from the operating office to the semaphore signal post is 1100 feet, and is partway along a 4 and a 6 degree curve.

Instead of leading the wire through a long wooden box, supported on small pulleys, as is usually done, above the surface of the ground, it was decided to try the experiment of running the wire through a pipe filled with oil, buried below the surface of the ground. A trench, averaging fifteen inches in depth, was dug along a carefully laid out line; stakes eight feet apart were driven along the bottom of this trench, so that their tops should come to a uniform grade line, which, in this case, was about 66 feet per mile; upon the tops of these stakes the $\frac{3}{4}$ inch galvanized iron pipe was fastened, so as to hold it in as true a position as possible.

A number 15 iron wire was strung through each piece of pipe as they were screwed together, so that it might be used to draw the signal wire through the pipe line after it was all laid. The pipes were all carefully examined and cleaned; a number had to be rejected on account of lumps of iron or galvanizing material obstructing the bore of the pipe. After the pipe was all laid, the $\frac{3}{16}$ inch iron signal wire was stretched out with block and tackle to straighten it and take out all the short kinks, and it was then pulled through into its proper position in the pipe by the smaller wire that had been strung through during the laying of the pipe; a small brass stuffing-box was screwed to each end of the pipe, through which the ends of the leading wire were passed. These stuffing-boxes prevent the escape of the oil. The ends of the pipe being thus closed up, it was filled with common car lubricating oil, mixed with about one-quarter part of refined coal oil,

to keep it from thickening in cold weather. The filling was done through a short upright branch pipe, attached at the highest end of the pipe.

The lever by which the distant signal is operated at the signal office, by the same movement turns four signal boards on the tower; and during the summer the usual counterbalance on the semaphore signal post, adjusted to exert its least weight, would operate the arm on the signal post and revolve the signal boards on the tower; during the colder weather the lubrication is possibly slightly stiffened, so that this same counterbalance barely turns the signal boards in the tower, and must have slight assistance.

The experiment has proved very successful thus far in the severe weather of this winter, and the apparatus has required no attention since being placed in position.

The apparent advantages of this plan are:

1. A very permanent and lasting arrangement.
2. Freedom from disturbance or accident to the signal wire.
3. Entire freedom from the difficulties caused by expansion, if the pipe is laid below the frost line; and subjection to but slight changes caused by change of temperature, if laid only one foot under ground.
4. Obviating the necessity to provide angle fixtures to change the direction of the wire around curves.

The difference in cost of materials per 100 feet is but a trifle; being $5.38 for the pipe plan, and $5.42 for the wooden box plan. The difference in labor would depend upon the character of the ground, but in most cases it would be nearly the same.

XXIV.

THE STEEL RAIL DISCUSSION.

By F. H. Lewis, Active Member of the Club.

Read March 20th, 1886.

During the past year, at least two prominent Western railroads have made vigorous protests to the steel rail manufacturers in regard to the wearing qualities of the rails they were receiving.

The charge was that the rails crushed out at the ends, and spread out on the sides, after a very short term of service.

To emphasize the matter, this complaint was specifically made against the product of the last few years; older rails standing up to the traffic very satisfactorily. For the matter of that, however, new rails always do wear rapidly, until they are worn to a full bearing under the wheels, so that there is no conclusive proof that the new rails were inferior to the older ones. The weight of traffic has increased very much in the last few years, and the older rails were not subjected to such duty at the outset.

There can be no question, however, that the complaint against the rails had abundant foundation in fact. Both the railroads in question have taken decisive measures to remedy the trouble, and the mills have generally given the matter consideration.

In the technical press there has been a wide range of comment, and a thorough ventilation of the whole subject. The fact that these complaints appeared at the time when rails were cheaper than ever before, has not been overlooked. One journal of wide popular circulation went so far as to say that the demand for cheap rails had led the mills to produce rails with a large percentage of ashes and slag in their composition.

To cheapen a product is always a legitimate field of endeavor, and the manufacture of rail steel has undoubtedly been modified with this intent. Whether the changes have been advantageous or not, is a matter for the railroads to determine, and not for the mills. The railroads undoubtedly get all they pay for, and I hold there is no conclusive proof that they do not get as good rails as they ever did.

The cardinal point in the whole matter is that the rolling stock has increased in weight beyond the strength of the rails, and the problem is to produce rails which will carry the rolling stock; and it is the object of this paper, not so much to answer this question, as to show what resources the manufacturer has at his command to affect the quality of his rails.

We hear a great deal about "hard" steel and "soft" steel, and we have heard of steel which is "chemically hard and physically soft." I wish to maintain at the outset that "hard" or "soft," as applied to rails, is a chemical quality and not a physical

quality; and I do this advisedly, holding that the physical quality desired in rails is not the "hardness" of cast iron as distinguished from wrought iron, but the greater strength or cohesion, as shown by a tensile strain; and this physical strength or cohesion in a piece of steel is measurably independent of the chemical composition. It depends on an entirely different matter, insomuch that you can give the same piece of steel widely different tensile strengths. The cohesion of a piece of steel depends upon the amount of work which is put into it.

An ingot of rail steel is 12 inches in diameter, porous through the middle and on the outside surface. The metal is white and crystalline, and has little tensile strength or ductility. The ingot is rolled down in a blooming train to 7 inches square, reheated, and put into the rail train. After eleven passes of the rolls, it issues at a bright red heat, finished to the rail section. A specimen, cut from the finished rail, will show a tensile strength probably less than 80,000 lbs. per square inch. If this steel had been rolled into plates or angles, it would have shown a tensile strength of 100,000 lbs. If the rail had been finished at a lower temperature, it would have been stronger. If in any way more work had been put into the steel, the rail would have developed more strength.

The ordinary manufacture of rails develops the strength of the steel to a moderate degree only, while there are at command a number of ways of putting more work into the rails.

Chemically we are using a manganese steel for rails; a steel which (excluding carbon) has a higher percentage of impurities than steel for any other purpose. The Bessemer process is not adapted to removing impurities from the metal, and it has not been considered necessary to use better metal than the Bessemer converter will produce from hæmitite pig iron. By varying the percentage of impurities, rails may be given physical qualities varying from a tensile strength of 60,000 lbs. with 25 per cent. stretch, to 100,000 lbs. with less than 5 per cent. stretch.

Practically in the rail mills of this country the qualities of the rails are modified solely by changes in the chemical composition; the physical treatment is the same. Such being the case, an endeavor will of course be made to find a remedy for the recent failures by means of chemical changes in the steel.

Mr. C. P. Sandberg, the English inspecting engineer, has recently advocated this in a paper read before the British Institution; a paper avowedly called forth by the failures of rails in this country, as rehearsed at the outset of this paper. He proposes a harder rail, and a heavier section to make it safe from fracture. There is nothing novel in the suggestion. It can be done in any mill without an hour's delay, or a dollar's expense, and must be adopted for the time being, to remedy crushed rail ends.

But where is this hardening of rails going to end? Traffic and the weight of rolling stock increases with every decade, and it is pertinent to ask if this hardening of rails must keep pace with these things. Each increase in the hardening elements decreases the toughness of the steel, and increases the chances of broken rails. To increase the weight of the section, affords perhaps a remedy for this, but at an immediate increase in first cost. We have good reason for thinking also that every decrease in toughness decreases the wearing power of the metal. The idea that hardened steel is the best to resist wear or attrition, has been pretty thoroughly exploded. There is abundance of experimental and practical evidence, showing that the best steel for wear is the steel which carries its strength with the least loss of ductility.

It is morally certain that the entire question will come up for investigation, and that the working of the metal will receive quite as much attention as its chemical composition.

The annual rail bill of $35,000,000 is too large an item to escape the attention of railway economists. Proof will certainly be demanded that the money is expended to the least advantage. Much old straw will be threshed over.

And it is the confident belief of the present writer, that the improvements in steel making in the immediate future will be in the direction of heavy forging, a better working and development of the material.

TABLE OF CHAINS EXPRESSED IN FEET.

November 7th, 1885.

Chs.	Feet.	Chs.	Feet.	Chs.	Feet.	Chs.	Feet.	Chs.	Feet.	Chs.	Feet.
1	66	26	1716	51	3366	76	5016	101	6666	126	8316
2	132	27	1782	52	3432	77	5082	102	6732	127	8382
3	198	28	1848	53	3498	78	5148	103	6798	128	8448
4	264	29	1914	54	3564	79	5214	104	6864	129	8514
5	330	30	1980	55	3630	80	5280	105	6930	130	8580
6	396	31	2046	56	3696	81	5346	106	6996	131	8646
7	462	32	2112	57	3762	82	5412	107	7062	132	8712
8	528	33	2178	58	3828	83	5478	108	7128	133	8778
9	594	34	2244	59	3894	84	5544	109	7194	134	8844
10	660	35	2310	60	3960	85	5610	110	7260	135	8910
11	726	36	2376	61	4026	86	5676	111	7326	136	8976
12	792	37	2442	62	4092	87	5742	112	7392	137	9042
13	858	38	2508	63	4158	88	5808	113	7458	138	9108
14	924	39	2574	64	4224	89	5874	114	7524	139	9174
15	990	40	2640	65	4290	90	5940	115	7590	140	9240
16	1056	41	2706	66	4356	91	6006	116	7656	141	9306
17	1122	42	2772	67	4422	92	6072	117	7722	142	9372
18	1188	43	2838	68	4488	93	6138	118	7788	143	9438
19	1254	44	2904	69	4554	94	6204	119	7854	144	9504
20	1320	45	2970	70	4620	95	6270	120	7920	145	9570
21	1386	46	3036	71	4686	96	6336	121	7986	146	9636
22	1452	47	3102	72	4752	97	6402	122	8052	147	9702
23	1518	48	3168	73	4818	98	6468	123	8118	148	9768
24	1584	49	3234	74	4884	99	6534	124	8184	149	9834
25	1650	50	3300	75	4950	100	6600	125	8250	150	9900

EXAMPLES.—Given, 78 chains 93 links.

78 chains (from the table), . . 5148.
93 links (from the table) 93÷100 61.38
78.93 chains = 5209.38 feet.

Given, 967 chains.

900 chains (90×10), . . 59400
67 chains, ... 4422
63822 feet.

ABSTRACT OF MINUTES OF MEETINGS.

Of the Club.

October 17th, 1885.—Regular Meeting.—This was the first meeting of the Club in its New House, No. 1122 Girard Street. President J. J. de Kinder in the chair, 62 members and 4 visitors present. In opening the meeting, President de Kinder offered a few words of welcome and congratulation to the Club, and asked that additional interest be taken in completing the appointments of our very pleasant quarters.

The Secretary announced that the alterations to the building, the finish and the furnishing, had been executed under the professional direction of Mr. T. Roney Williamson, Architect, Member of the Club, who had not only consented to volunteer this service, but had given personal and careful attention to every detail—so that we had been enabled to expend the available funds to the best advantage. A Committee, consisting of Messrs. See, Graff and Marshall, was, on motion, appointed by the President to express to Mr. Williamson our appreciation of his services.

The Secretary presented, for Mr. P. F. Brendlinger, an illustrated description of a novel and cheap Cement Testing Machine.

Mr. John T. Boyd presented an illustrated description of the "Coventry" Locomotive Boiler.

The Secretary presented, for Mr. Walter C. Brooke, a description of appliances for Landing Mine Cars at the Top of Slope.

Mr. A. Marichal, visitor, exhibited and described an instrument for at once describing arcs, of any radii from a few inches to infinity, and for determining the radii of arcs already drawn. It operates upon the general principle that all angles inscribed in the same segment are equal, and it is adjusted or read by means of graduations.

Mr. T. M. Cleemann, on behalf of Mr. W. W. Evans, of New Rochelle, N. Y., presented a small box, made of White Oak from Delaware River Bridge at Trenton, N. J., built in 1803; replaced by an iron bridge in 1875; in constant service for 72 years, and as a railway bridge for 30 years.

A copy of the first edition of the *American Engineering Register*

was presented by the author, Prof. L. M. Haupt. It is a work of 518 pages, containing rules, tables and formulæ, and the names, addresses, occupations, etc., of all classes of engineers, and a list of railroads and their officials. It has already met with very flattering notices from the technical reviewers. In presenting it, the author read some extracts from its pages, in behalf of a more general recognition of the services of the profession by the public, and made some comments on the effects of engineering works in promoting the general welfare of any community.

The Secretary presented, for Mr. P. T. Osborne, a copy of Vol. I of *Select Plans of Engineering Structures for Railroads and Highways*, by Mr. Richard B. Osborne, C.E. It contains full general and working drawings, with bills of quantities and detailed costs, of a large number of actually executed structures, giving it a value which will be highly appreciated among practical engineers.

The Secretary announced that a Committee of the Civil Engineers' Club of Cleveland desired that this Club participate in joint action with their and other Societies for the purpose "of obtaining the passage of new laws which shall provide for the better condition of Civil Engineers employed on Government works, other than military." Not being a business meeting, no action could be taken, but the matter was, by informal vote, referred to the Board of Directors.

The Secretary reported that the assessment of a considerable amount of customs duty upon books presented to us by the British Government, had been made the occasion for a determined fight for our heretofore disputed right to free entry. After unlimited affidavits, blanks, bills, bond and other documents, including "Hospital dues" (on Abridgments of Specifications of British Patents!) in getting it there, the appeal to the Secretary of the Treasury met with prompt and fair consideration. We are now, officially, "a Society established for philosophical purposes, and entitled to the benefits conferred by the provision of the law above quoted." (Free List.)

November, 7th, 1885.—Business Meeting.—Past President Henry G. Morris in the chair; 45 members and 4 visitors present.

Messrs. Louis C. Madeira, Jr., and C. Frederick Moore, the Tellers of Election, reported that the proposed Amendment to Article IV of the Constitution was not adopted; and that the following gentlemen were elected Active Members of the Club: Messrs. Joseph B. King, John W. Campbell, Col. Wm. P. Craighill, R. R. Bridgers, Jr., George E. Datesman, Allan Cox, Henry E. Tripler, J. H. Covode, John Wilson, Pedro G. Salom, Theo. Low, Jacob B. Rohrer, Emile Low, Sutherland M. Prevost, and Chas. S. Churchill.

The Secretary read extracts from various communications from Mr. Wm. T. Blunt, Secretary of Committee of Civil Engineers' Club of Cleveland, relative to the proposed Convention of representatives of the Engineering Societies at Cleveland, December 3d to 5th, 1885, "to consider and report what action, if any, is advisable in the matter of obtaining the passage of new laws which shall provide for the better condition of Civil Engineers employed on Government Works, other than Military." In response to the invitation to the Club to send a representative to this Convention, the Secretary nominated Mr. E. L. Corthell, who was unanimously elected by the meeting.

The Secretary presented an informal report of progress in the completion of the furnishing, etc., of the New House.

Mr. Horace See, Chairman of Committee appointed to convey to Mr. T. Roney Williamson, Architect, Member of the Club, the thanks of the Club for his professional services, presented the following communication to Mr. Williamson for approval, which, on motion of the Secretary, was heartily endorsed by unanimous vote.

Philadelphia, November 7th, 1885.

Mr. T. Roney Williamson, Architect.

Dear Sir—The Engineers' Club of Philadelphia at its last meeting, Oct. 17th, appointed the undersigned a Committee to express to you its appreciation of your services during the alteration of the House, wherein you have shown such good judgment and taste.

On its behalf we wish to thank you for the successful manner in which the various details have been carried out to make it both convenient and comfortable. Also for the generosity displayed in volunteering your time, much of which must have been taken up in supervising the alterations, in purchasing the different articles, and in seeing to your plans being properly carried out.

Very respectfully,

Horace See,
Frederic Graff,
Samuel R. Marshall.

Mr. F. H. Bowen, Jr., presented a description of the Albo-Carbon Light.

Mr. James Christie presented a paper upon the Adaptation of Steel to Structural Work.

The Secretary presented, for Mr. H. W. Clarke, a Table of Chains, Reduced to Feet, for the Reference Book.

Mr. Rudolph Hering read some interesting extracts from a Report of a Committee of the City Councils of Philadelphia, made in 1801, on the first works built to supply the city with water from the Schuylkill River, the Pumping Station of which was at Centre Square, on the site of the present City Hall.

Mr. Henry G. Morris exhibited a fine specimen of a copy of tracing in Blue Lines on White Ground.

Mr. Wilfred Lewis moved that it be the sense of the Meeting that smoking be prohibited in the meeting room during sessions. Mr. C. A. Ashburner offered as an amendment that the question be referred to the House Committee. The motion, as amended, was carried. The sense of the meeting was then taken by a standing vote with the following result: In favor of smoking being permitted, 14; against smoking being permitted, 9.

November 21st, 1885.—Regular Meeting.—Past President Rudolph Hering in the chair; 60 members and 4 visitors present.

The Secretary presented, for Mr. W. S. Church, a large number of photographs, tracing, pamphlets and other documents, illustrating the design and progress of the New Croton Aqueduct, and read two communications from Mr. Church.

Mr. Jno. S. Elliott presented a paper on Specifications as Affecting the Dimensions of Iron R. R. Bridges.

A discussion followed upon the paper of Mr. James Christie, upon the Adaptation of Steel to Structural Work, by Mr. Thos. M. Cleemann, the Author and Prof. Wm. H. Burr.

Mr. Geo. S. Strong presented an illustrated description of Rack Rail Appliances for railroads with very heavy grades.

Mr. J. Foster Crowell presented an illustrated paper upon Masonry Arches.

Mr. A. R. Roberts exhibited and described an appliance for Fastening the Floor Timbers of Highway Bridges.

Mr. Henry G. Morris introduced Mr. P. Oestburg, who exhibited specimens of and described the Mitis Metal Castings.

Mr. Wm. H. Dechant presented a description of a Movable Dam and Caisson Operating Truck, illustrated by a small model and lithographs.

The Secretary announced the death of our fellow-member, Mr. Dwight Edward Pierce, and Mr. M. W. Rudderow presented a narrative of his experience and achievements, as a Memorial for publication in the Proceedings.

December 5th, 1885.—Business Meeting.—President J. J. de Kinder in the chair; 35 members and 1 visitor present.

The Tellers of Election, Messrs. John T. Boyd and E. S. Hutchinson, reported that 114 ballots were cast, and that the following candidates were elected Members of the Club. *Active:* Messrs. E. B. Wingate, Henry C. Zacharias, Louis G. Laureau, Fred. W. Gordon, W. M. Patton, Victor O. Strobel, A. Saunders Morris, A. B. Broomell, Howard Wood, Wm. F. Mencke, and Lewis N. Lukens. *Associate:* Messrs. Frank K. Esherick, and L. Frank Gordon.

Messrs. Rudolph Hering and Henry G. Morris were announced as the House Committee of the Board of Directors, under the new By-Laws. They reported that they had considered the question of smoking being permitted at the Club meetings, which was referred to them by the Nov. 7th meeting, and recommended that the question be referred to a letter ballot by the Club, which recommendation was adopted.

The Secretary presented circulars from Committees of the Engineers' Club of St. Louis and the Civil Engineers' Club of Cleveland, with regard to the Convention to consider the status of Civil Engineers in the Government service—but no action was taken thereon, as the Club had already elected a delegate to represent it at the Convention.

The Secretary presented a communication from Mr. W. H. Ridgway, recommending that any professional question which might arise in the experience of any Member, be presented to a Committee of the Club, and referred, for solution or answer, by that Committee to some Member, whom the Committee considered

to be experienced in the specialty to which it referred. No objection was offered to the adoption of such a measure, but no action was taken.

Officers, to serve during 1886, were nominated.

Mr. John T. Boyd, for Mr. Washington Jones, presented to the Club, and described, some specimens of Artificial Fuel made in Belgium.

Mr. Boyd also desired to make an acknowledgment of his indebtedness to Messrs. Elliott Brothers, opticians, of London, England, and Mr. A. Amsler, the inventor, for information of value in regard to the correct methods of working the Polar Planimeter, which they very kindly sent him, and which he is now arranging in a convenient form for the Club Reference Book. Mr. Boyd's correspondence was with Messrs. Elliott Brothers, and was by them referred to Mr. Amsler for detailed reply.

Mr. C. W. Buchholz presented a paper of more than ordinary interest upon "Engineering: its Achievements and its Reward."

On motion of Mr. E. S. Hutchinson, the special thanks of the Club were tendered to Mr. Buchholz for his very interesting and entertaining paper.

December 19th, 1885.—Regular Meeting.—Past President Henry G. Morris in the chair; 59 members and 2 visitors present.

A Report was presented by Mr. E. L. Corthell, our delegate to the Convention of Civil Engineers held at Cleveland, December 3–6, on the Status of the Civil Engineering Profession on National Public Works of a civil character.

The Societies represented in the Convention, or who had selected delegates, were seventeen in number, with a total membership of 2062. Although coming from distant sections of the country, the views of the delegates harmonized from the first, and the desire to accomplish results of practical benefit to the Engineering Profession and to the Country, led to wise and conservative action on the part of the Convention; all personal or peculiarly class interests were made subservient to the higher purpose of the interests of the Country and the Profession. The views of the Convention are embodied in the reports of its committees, which briefly, but comprehensively, state the facts and

lay out the future work of a permanent organization. These reports are as follows:

To the Convention representing the Civil Engineering Societies of the United States by their delegates assembled at Cleveland, Ohio:

GENTLEMEN:—Your committee on "The report of the action of the Convention, said report to be submitted by the delegates to their respective Societies," respectfully submit the following as their final report:

The foremost nations of the world have organized systems of internal improvements. The United States at present has no such system. The marvelous development of this great country demands some adequate organization of such a system.

In the formation of such an organization, advantage should be taken of the best features of the systems of other nations.

The main reason for the success of such works in foreign countries is due to the fact that they are executed under a civil administration, although the governments themselves, in other respects, are more essentially military than our own.

The distinguishing feature of these organizations is the employment of the best available talent, of men especially fitted by education, training and experience, to design and execute such works.

Under our present methods the government cannot possibly secure such trained skill. The reason is that no emoluments or reputation, commensurate with the service rendered, or equal to what can be obtained on other civil works, are attained on the public works of our government.

These facts deter men of experience from entering the service of the government, and also those who have gained experience therein, from remaining in its employ.

Recognizing that a comprehensive system of Public Works is necessary, we respectfully suggest that Congress should be asked to establish a Civil Bureau of Public Works; the basis of organization of this bureau to be made the subject of study, and report, by a board appointed by the President of the United States; said board to consist of seven members, three military engineers, three civil engineers, and one member of the legal profession.

MR. CHAIRMAN:—Your Committee to perpetuate the work and to further the objects of this convention, beg leave to submit the following report:

1st. We recommend that each organization in the United States embracing Civil Engineering be requested to appoint a permanent Committee on National Public Works, and also to empower and direct the Chairman of that Committee to be a full member of the Civil Engineers' Committee on National Public Works.

2d. Said Committee to perfect its organization and choose an Executive Board of five members. The President of the Committee to be President of said Board. Its Secretary shall not be a member thereof.

3d. The Executive Board may select from each important city or section of the country, one or more Engineers as corresponding members of the Committee.

4th. Vacancies in the Committee to be filled by the Society whose seat is vacated.

5th. Vacancies in the Executive Board to be filled by vote of the regular members of the Committee, by letter ballot, upon nominations made by the Executive Board.

6th. The duties of the Executive Board shall be the dissemination and presenta-

tion of the action of the meetings of the Committee and other information, to the Engineering profession, to Congress and to the country at large.

7th. We further recommend that for the present, the delegates to this convention constitute a temporary Committee and act as such until the doings of this convention are acted upon by the organizations who have appointed delegates.

Whenever a Society takes favorable action, the Chairman of the Committee on Public Works of that Society shall become the successor of the present temporary incumbent and a member of the permanent Committee:—and on the first of April, 1886, the permanent organization shall go into effect.

The earnest closing words of the President of the Convention speak with no uncertain tone its high purposes and patriotic motives.

Closing address of the President of the Civil Engineer's Committee on National Public Works.

DELEGATES TO THIS CONVENTION AND VISITORS.

GENTLEMEN:—This convention is about to terminate, but provision has been made for continuing its work. The question before us is one of grave importance to the State. Its wise solution involves an economic problem of momentous consequence in the future. Thus impressed, if we have failed in recommending wisely we must bespeak for our National Committee the consideration and the co-operation of all who have the public weal at heart. A singular unanimity of opinion has prevailed, as of mature study which could reach but one conclusion, and we therefore with the greater confidence refer our action to our respective Societies, and to all others not here represented, for their ratification and cordial support. We work not for to-day nor tomorrow, but for that best end which may choose its means. If thereby our great Profession may rise higher in our mature development, then, indeed, have we to-day cast our bread upon the waters.

The history of the last eleven years shows that the Civil Engineering Profession has obtained recognition on some of the most important public works ever undertaken by this or any other government; this recognition was obtained by Memorials to Congress and by a representation of the subject in Congressional Committees. The members of our Profession have served the Government on these works in important positions and on a perfect equality in every way with the members of the Military branch of the profession who were associated with them. The Civil Engineers of the country believe that a reorganization of the system of National Public Works, particularly of Rivers and Harbors, on a civil basis, will give the Government an opportunity of calling to its aid the best skill and experience; which, under the present system, as stated by the Chief of Engineers,

U. S. A., in a recent letter, it cannot obtain; for "there has been little inducement for experienced Civil Engineers to offer their services to the Government." Cogent reasons for a change in the methods employed on Government Works and the importance of this change, are stated as follows in the following abstracts from a Memorial drawn up for presentation to Congress:

"Your petitioners are Civil Engineers, and we address your "Honorable Body in regard to the general policy of the Govern-"ment in executing its Civil Engineering Works, especially those "looking to the improvement of our Rivers and Harbors.

"Up to the recent past the work undertaken by the General "Government for the benefit of commerce has been unimportant "and of small extent; but some ten or twelve years ago the needs "of commerce compelled the Government to begin a more scien-"tific class of work and far more extended, requiring also more "systematic application in the execution of the works. The de-"terioration of our rivers, as our great country became more thor-"oughly opened up, began to be sensibly felt; and the increasing "draught of ocean and lake steamers made it necessary to devise "measures for removing the bars that obstructed the entrances to "our harbors. Thus we were confronted with a state of things "that called for the highest attainments in Civil and Hydraulic "Engineering.

"It is important to take a comprehensive view of the require-"ments, which this rapid increase in the demands of commerce "have imposed upon the Engineering Profession. The works re-"quired cannot be undertaken or performed by the meagre and "disjointed expenditures of the past. Nor are we likely to derive "satisfactory results from expenditures upon undertakings of this "kind, unless we can conform more to that division of labor, to "that employment of specialists, such as is practised by corpora-"tions, companies and individuals in their great enterprises, and "also, in the conduct of their Civil Engineering works, by other "nations of eminence in the world, except our own. Already our "annual estimates are nearly $50,000,000. The total amount "necessary to complete the works now begun, must be hundreds "of millions of dollars. It can hardly be expected that any con-

"siderable part of the improvements already commenced will be "dropped from the list, and new works of commanding import- "ance are clamoring for recognition.

"About sixty military engineers, educated specially for the art "of war, and for the construction and maintenance of the defenses "of the country, have now placed upon them the onerous duty "and responsibility of surveying, designing and executing these "great public works. There are, however, a large number of "Civil Engineers employed as assistants on these works, who per- "form for the Military Engineers in charge much of the engineer- "ing work stated above. They are, however, not in a position "where they can be of the most service to the Government, for the "positions held by them temporarily, are such as to lead them to "simply perform a specific duty under the orders of a military "superior, through whom all their work, surveys, plans, reports "and estimates, must go to the Secretary of War. The undesir- "ableness of the positions held by them, leads to their early res- "ignation to obtain more congenial and profitable employment, "and more conducive to progress in their profession, and to the "reputation that comes, where merit, faithfulness and experience "meet with their reward, on the great civil works of the country, "conducted by States, cities, corporations, companies or individ- "uals. This anomalous position of Civil Engineers in the service "of the General Government makes it utterly impossible for the "country to obtain the highest skill and the most valuable expe- "rience on its important River and Harbor works.

"The present system, therefore, does not and cannot result in "that hearty co-operation in all its essential elements that is ab- "solutely necessary for the highest efficiency, either in the com- "mercial result, which these works are intended to accomplish, "or in the economy of funds appropriated for their construction "and maintenance.

* * * * * * *

"We urge that a remedy for existing evils is as much needed "by the Government as by ourselves, and, as citizens, we ask for "its application. The Military Engineering should be separated "from the Civil Engineering. A bureau of Civil Engineering "should, in our opinion, be organized and placed under one of

"the divisions of the Government. It need not be larger than "the present needs of the Government require. There are Mili- "tary Engineers who, by reason of the experience of recent years, "are competent to be put in charge of such works. They might "be assigned to that duty, their rank and pay as officers in the "army being discontinued, while employed in a civil capacity, "without detriment to resumption in case of war or need of their "services in their own pursuit. But the Government should, we "think, contemplate the ultimate composition of this corps of "Civil Engineers, exclusively, in order that our national works, "as they are completed, can be cared for and maintained by "officers, not subject to detail with consequent neglect of the "works in time of war; and that we may have the benefit of spe- "cialists, educated and trained for the work in hand. The some "one hundred and twenty Military Engineers, maintained by the "Government, will be, by no means, a large staff for devising, "constructing and maintaining defenses for our vast coast, attend- "ing to the inland works and defenses that are maintained, and "keeping pace for our country, with the progress of the science "of war, which, in this age of wonderful progress, undergoes the "most radical changes almost yearly.

"*The civilians should improve a country, the military men should* "*defend it.* There will be no difficulty in organizing a very able "corps of Civil Engineers from among the seven thousand or "eight thousand members of that profession in our country.

"As the works for the benefit of commerce will always be con- "structed by the General Government, and as the experience of "other countries, and the pressing demands of our own, lead us "to expect that before the end of this century our annual expen- "ditures will be much greater than they are now—greater than "we shall spend upon either our army or navy establishments, "and be long continued, we respectfully suggest to Congress the "establishment of the Civil (River and Harbor) Works of the "Government on a Civil basis, its composition to be entirely Civil "and drawn from that portion of the Engineering Profession of "the country that are especially educated and trained in Hydrau- "lic Engineering. The members of this Civil Department should "be selected, given positions, retained, discharged, relieved and

"promoted to higher positions in their departments, according to "ability, experience, faithfulness and length of service, whether "they are from civil life or take position in the Civil Corps by "resignation from the Army or the Navy."

A large number of the most experienced and thoughtful men in the Civil Engineering Profession have signified their earnest wish to assist in the work that now lies before the National Committee and before the Profession in this country. Included among them are four Past Presidents of the American Society of Civil Engineers, several of its Vice Presidents and Boards of Direction. Members of other Societies and individuals, from California to Boston, and from the North to the South, have taken hold of the matter in earnest, and it is hoped that the united action of the Societies and individual members of the Profession will serve to bring this important subject forcibly to the early attention of our Government, and lead to the solution of a question that, if wisely solved, will be for the great advantage—first, of the Country, and second, of the Engineering Profession.

The Secretary called upon Prof. L. M. Haupt, who had been identified with both the Military and Civil branches of the profession, for an expression of his views, which drew from the Professor a hearty endorsement of the statements and ideas advanced by Mr. Corthell.

The Secretary made inquiry as to what expense had been incurred by Mr. Corthell as our representative—to which Mr. Corthell replied that he had no account to render for any personal expenditures, and that the general expenses of the Convention have been borne by the gentlemen who have thus far taken so unselfish an interest in this important public and professional question. The Secretary felt sure that the Club always desired to pay its share of the expense of any movement in which it participated, and Mr. Corthell stated that it was intended to recommend the division of future expenses among the organizations represented, according to their relative strength.

A hearty vote of thanks was tendered to Mr. Corthell for the able and thorough manner in which he had discharged his duty as our representative.

The Secretary noted that, as this was not a Business Meeting,

we could not take any action that would be binding upon them, but thought that if the Board of Directors were made aware of our sentiments, they could proceed with more freedom in the selection of a permanent Committee on National Public Works, and therefore moved that we express our sentiment in favor thereof, and request the Board to take such action, which motion was carried by unanimous vote.

Mr. Thomas C. Clarke, through Mr. Thomas M. Cleemann, presented an account of the impressions gained by him last summer during a visit to the Forth and Tay Bridges.

Mr. John T. Boyd presented, for the Brooks Locomotive Works, of Dunkirk, N. Y., two handsomely framed photographs of locomotive engines.

The Secretary presented, for Mr. S. P. Mitchell, Tables for Finding Ordinates to Circular Arcs, for the Reference Book.

The Secretary, on behalf of two members, pursuant of the recent suggestion of Mr. W. H. Ridgway, presented the following questions, which were partially discussed at the meeting:

No. 1. Suppose a shaft sunk to a depth of 75 or 100 feet through a somewhat broken rock, be divided into two compartments, 10 ft. by 10 ft. and 5 ft. by 10 ft. in area, respectively; the shaft timbered tightly with planks and the only communication between the two compartments being at the bottom. Why is a strong *upward* current of air experienced in the smaller?

These were the conditions in a shaft in a mountain some 10,000 feet above sea level. There was no steam or other artificial heat at the bottom, nor was the temperature in the shaft very different from that of the outside atmosphere.

No. 2. *a.* What proportion of piston area should area of air inlet and outlet valves be on a blowing engine with a stroke of 48 ins.; cylinder, 54 ins. diameter; maximum speed, 30 revolutions per minute; blast pressure, 25 lbs. per square inch.

b. Also on a blowing engine with a stroke of 60 ins.; cylinder, 70 ins. diameter; maximum speed, 40 revolutions per minute; blast pressure, 15 lbs. per square inch.

Qustion No. 1 was stated and illustrated by diagram, by Mr. T. M. Cleemann, on behalf of the member offering it.

The Secretary also informally presented a question in hydrau-

lics which had been the subject of decided difference of opinion, and gave the answer as derived by theory and actual experiment.

January 9th, 1886.—Eighth Annual Meeting.—President J. J. de Kinder in the Chair; 45 members present.

The Secretary and Treasurer presented his Annual Report.

On motion of the Secretary and Treasurer, his accounts for 1885 were referred to the Finance Committee of the incoming Board of Directors for audit.

The Secretary presented the resignations from Active Membership of Messrs. T. Everett Austin, W. Irving Babcock, James Beatty, Jr., C. John Hexamer, Andrew B. Lauffer, Thaddeus Norris, Arthur Winslow and L. M. Winston, which were accepted.

The Retiring President, Mr. Joseph J. de Kinder, read the Annual Address.

The Tellers of Election, Messrs. E. S. Hutchinson and C. Frederick Moore, reported that the following had been elected

Officers for 1886.

President—Mr. Washington Jones.

Vice-President—Mr. Thomas M. Cleemann.

Secretary and Treasurer—Mr. Howard Murphy.

Directors—Messrs. Frederic Graff, Rudolph Hering, William A. Ingham, Col. William Ludlow and Henry G. Morris.

Active Members—Messrs. Albanus L. Smith, Samuel T. Williams, Robert E. Pettit and H. R. Cornelius.

They announced that the vote upon the question of allowing smoking at the meetings had resulted as follows:

In favor of smoking being permitted . . .	102.
Opposite to " " " . . .	101.

Mr. Washington Jones took the chair for 1886 with appropriate remarks.

January 16th, 1886.—Regular Meeting.—President Washington Jones in the chair; 24 members present.

Mr. Howard Constable gave an interesting account of the system used in London for the Public Supply of Hydraulic Power.

Mr. Constable also described a novel Rubber Spring for tram-cars, railway draw-bars, buffers and the like.

Prof. L. M.Haupt read a profusely illustrated paper on Harbors.

Messrs. Coleman Sellers, Jr., Chn., Wilfred Lewis and M. R. Mucklé, Jr., were appointed a committee to prepare a Memorial of the late Theodore Bergner.

Answers to Question No. 1 (Dec. 19th, 1885) were presented by Messrs. James Christie and Louis Schutte.

Februray 6th, 1886.—Regular Meeting.—President Washington Jones in the chair; 41 members and 2 visitors present.

The Secretary presented, for Mr. A. R. Cruse, a compilation of tests of the efficiency and economy of various Gas Burners.

The Secretary presented, for Mr. Mataro Crizuka, a paper, illustrated by Japanese map, upon the Railways in Japan. The history of the present railways is given, and the projects for the future. The paper treats of costs per mile; the bridges, tunnels, shops, etc.; the methods of operation; the profits of the traffic; the native and foreign supervision and labor; and the relations of the Government and private enterprise to the work.

Prof. L. M. Haupt read a second paper on Harbor Studies.

Mr. J. Foster Crowell read a paper upon the Present Situation of the Interoceanic Canal Question.

The Secretary presented, for Hon. J. Simpson Africa, Chn., Prof. L. M. Haupt and Mr. A. E. Lehman, Committee, a Memorial of the late Col. James Worrall, giving a very interesting account of his connection with the early and later engineering works of the country.

February 20th, 1886.—Business Meeting.—President Washington Jones in the chair; 38 members and 2 visitors present.

The Tellers of Election, Messrs. J. Foster Crowell and George T. Gwilliam, reported that the following had been elected Active Members of the Club: Messrs. George R. Henderson, R. C. Luther, Llewellyn W. Jones, Samuel T. Wagner, Fredk. H. Lewis, Carl O. Lindroth, C. Phillips Bassett, Fredc. H. Robinson, W. L. Hoyt and Philip D. Borden, Jr.

Mr. J. Foster Crowell presented, in continuation of his discus-

sion of the Interoceanic Canal Question, an exposition of the engineering features embodied in the Nicaragua Ship Canal project in its latest form, illustrated by official maps and profiles of the country, harbors and route, accompanied by detailed plans of the dams, locks and other permanent structures furnished through the courtesy of Mr. A. G. Menocal, the Chief Engineer of the undertaking.

The Secretary presented a letter from Prof. J. E. Nourse, U. S. N., Correspondent, expressing the general views of Prof. Nourse upon the subject of Isthmian Transits.

Dr. H. M. Chance described some phenomena experienced in draining a mine by Siphons.

Prof. L. M. Haupt deferred his paper on the Delaware Breakwater Harbor until the next meeting, but explained, for the benefit of the members present, a dissected model, showing the condition of the bottom before the breakwater and ice-breaker were built, the position of those structures, the scour and deposits that had occured, and the work done by the currents in the various zones lying between the several fathom contours. The volumes moved were determined by weight, and important physical results were clearly and intelligibly illustrated. The character of the forces acting in this harbor, were, in the author's opinion, easily and readily determined from the changes which had been produced in the mould of the harbor.

A discussion of the general deductions and remedies was reserved for the next meeting.

The Secretary presented, for Mr. Walter S. Church, a complete set of the New Croton Aqueduct Specifications, handsomely bound, and the thanks of the Club were returned for the same.

March 6th, 1886.—Regular Meeting.—President Washington Jones in the chair; 29 members and 3 visitors present.

The Secretary presented, for Mr. Wm. H. Dechant, a description of a Practical Test to Operate a Distant Signal by a Wire Run through a Pipe Filled with Oil.

Mr. J. Foster Crowell exhibited, described and presented to the Club, a model, illustrating the Rolling Lock Gate, designed by Mr. R. E. Peary, Civil Engineer, U. S. N., for the Nicaragua Ship Canal.

Prof. L. M. Haupt continued his paper on Harbor Studies, applying the principles to the harbor of refuge at the Delaware Breakwater.

Mr. C. W. Pusey described Baird's Distiller, as used in the works of the Pusey & Jones Manufacturing Co., for furnishing distilled water for the men.

Wm. H. Derbyshire described a new double Lathe for Turning Steel Tired Car Wheels, and Mr. F. W. Gordon described a Lathe for the same purpose.

The Secretary, for Mr. J. H. Harden, called attention to a publication of the Chesterfield and Midland Counties Institution of Engineers, upon Davis' Self-Timing Anemometer.

The Secretary presented the following for Mr. James F. Wood: "The Atlantic City Drainage Company has discovered that many of the pipes were put down at wrong grades, and are now engaged in taking them up and relaying them at proper grades." I enclose above slip cut from Philadelphia paper. The only interest in it is the extraordinary fuss they made in the papers over criticisms of their *modus operandi* at Club meeting last winter.

March 20th, 1886.—Regular Meeting.—President Washington Jones in the chair; 25 members present.

Mr. Charles G. Darrach explained the principles involved in the construction of Intermittent Siphons.

Mr. Frederick H. Lewis read a paper on the Steel Rail Discussion.

Of the Board of Directors.

November 7th, 1885.—Special Meeting.—Past President Henry G. Morris in the chair.

The Secretary presented correspondence with a Committee of the Civil Engineers' Club of Cleveland, relative to a proposed convention to consider the status of Civil Engineers employed on Government Works other than Military. The question was referred to the Club for action.

December 19th, 1885.—Regular Meeting.—Past President Henry G. Morris in the chair.

Messrs. E. S. Hutchinson and C. F. Moore were appointed Tellers to conduct the Annual Election, with Messrs. John T. Boyd and A. Saunders Morris as Alternates.

The Secretary presented a communication from a member asking permission to use the second story of the Club for an evening for the entertainment of a few friends. After some discussion as to general regulations for such entertainments, it was ordered that, with the approval of the Board, such entertainments might be given, and that a uniform fee of Ten Dollars should be charged to cover the expense of light, heat, etc.

January 9th, 1886.—Special Meeting.—President J. J. de Kinder in the chair.

The Secretary presented the vouchers for the whole fiscal year 1885, Nos. 1 to 133, both inclusive, all of which had been approved by the Finance Committee, and the payment of the same was approved by the Board. In accordance with the request of the Club, the President was requested to appoint a Permanent Committee on National Public Works, whereupon he appointed the following: Mr. E. L. Corthell, Chairman, Prof. L. M. Haupt and Mr. Rudolph Hering.

The Board for 1885 adjourned *sine die.*

January 16th, 1886.—Regular Meeting.—President Washington Jones in the chair. The President announced the appointment of the following Standing Committees for the year 1886:

Finance—Messrs. Frederic Graff and Henry G. Morris.

Membership—Messrs Henry G. Morris and Wm. A. Ingham.

Publication—Messrs. Thos. M. Cleemann and Col. Wm. Ludlow.

Library—Messrs. Rudolph Hering and Thos. M. Cleemann.

House—Messrs. Wm. A. Ingham and Rudolph Hering.

The Secretary suggested that a request be extended to President Washington Jones to sit for his phototype portrait for insertion in our Proceedings. The suggestion was unanimously adopted.

March 6th, 1886.—Special Meeting.—President Washington Jones in the Chair. The Secretary was directed to take legal proceedings to recover an amount due the Club.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

Vol. V.] AUGUST, 1886. [No. 5.

XXV.

THE PRESSURE AND COMPOSITION OF NATURAL GAS.

By DR. H. M. CHANCE, Active Member of the Club.

Read May 1st, 1886.*

IN a paper discussing the "Anticlinal Theory" of Natural Gas† I have already shown that the pressure under which gas exists beneath the surface in Western Pennsylvania, must be limited by the depth of the gas producing stratum; it must, in other words, be less than the weight of the overlying rocks, which may be taken at one pound per square inch for every foot in depth. This determines the absolute maximum limit for any considerable area of gas-producing rock.

It is perhaps possible that the pressure is also limited by the hydrostatic head. We may distinguish two entirely independent hydrostatic pressures which might limit the gas pressure.

1. *Direct pressure* from stream level at the surface above the gas rock, acting through extremely narrow crevices and thus sealing the gas within its porous sandrock reservoirs. When the gas pressure exceeds this water pressure, the gas must blow off. After the pressure is sufficiently reduced, the water might again seal up

* Formerly Assistant Geologist, Pennsylvania Geological Survey.

† Read before the Bethlehem (1886) Meeting of the American Institute of Mining Engineers.

the vents. The gas pressure, if so limited, could not exceed $\frac{44}{100}$ pound for each foot in depth of gas sand below surface water level. Thus for 1500 feet below water level, the gas pressure limit would be about 650 pounds per square inch, or somewhat less than half the ultimate maximum as limited by rock pressure (weight).

2. *Hydrostatic pressure* acting through each rock from its outcrop at water level in the northern part of Pennsylvania, or southern New York. If we could admit the possibility of such perfect continuity of porosity, or open crevices, or both, as would permit the pressure to be transmitted through eighty or one hundred miles of rock underground from the water level outcrop of the first oil sand near Titusville on Oil creek, and below Tidioute on the Allegheny river, at an elevation above tide of about 1100 feet, through and down the slope of the rock to Pittsburgh where this rock lies about 800 feet *below* tide, then the maximum gas pressure possible would be limited by this difference in elevation.

The non-porous character of large areas of the rock, the clay luting of the rock joints (cleavage joints), render such an hypothesis improbable, but we have much stronger negative evidence in the salt water wells, many of which when first struck flow largely, but after a time as the gas pressure (from dissolved gas) diminishes, they cease flowing and in many cases the brine does not rise more than half way to the surface. If the hypothesis of open crevices or continuity of porosity were true, these wells should yield true artesian flows of constant volume.

The hypothesis of direct pressure from the surface is partly disproved by the experience of drillers throughout the oil region, that fresh water is found only to a certain depth,—usually 300 to 500 feet,—and that below this, and until salt water is struck,—commonly at 800 to 1400 feet, in the oil regions,—the slates and shales passed through are *extremely dry.* This dryness of the underground is not peculiar to the oil regions; in many mining districts the rocks at great depth are exceedingly dry, no water being met after passing below the limit to which the surface water penetrates. In some of our deep anthracite coal mines, and in deep coal mines in other countries the absence of moisture is such that much inconvenience is experienced from the accumulation of large quantities of exceedingly dry dust.

This fact, that surface water finds its way down to only a limited depth, is sufficient proof that nearly all the cleavage joints and fissures are filled with a practically water tight clay luting, and it is to this fact that we must attribute the possibility of the existence of large quantities of gas at great pressure. Without such a filling in of the cleavage joints and fissures, such accumulations would evidently be impossible.

Hence these hypotheses both seem to me improbable, and while they would, if true, establish pressure limits very nearly equal to the observed maximum pressures, I believe that this is merely a coincidence brought about in the following way.

We have no records of the gas pressure first shown by the larger wells. The recorded pressures have nearly all been observed after the gas had been blowing off for some weeks, months, or even years, and the pressure then shown by a guage is evidently no measure of the pressure under which the gas exists in the rock, for the gas soon becomes exhausted from the immediate vicinity of the well, which then draws its supply from a considerable distance, and perhaps through bands of rock of such texture (and perhaps even through the clay filling of crevices), that the pressure shown at the well may be only a fraction of the actual pressure.

Hence while recorded pressures range from about 600 down to 200 pounds per square inch, we have every reason to believe that the actual pressures are perhaps from 500 to 1000 pounds per square inch, or even in some cases much greater, but must still be less than the maximum as limited by depth. In the paper above mentioned I have shown that this maximum is very much less than the pressure necessary to effect liquifaction, and that we must therefore abandon the supposition that the gas exists as a liquid.

One of the most interesting phenomena recently observed in natural gas is its variability. The analyses of Prof. Sadler* made some nine years ago, told us that gas from wells located in districts not connected with each other was similar in composition, but that the percentages of the different gases present varied widely. We were, however, not prepared for the discovery that

* Report L, Pennsylvania Geological Survey.

gas from wells in the same "pool" and that from the same well was subject to daily and even hourly variations in composition. When it was found that the calorific value of the fuel was subject to change from time to time, as shown by variations in temperature of the furnaces, and in the steam pressure of boilers under which it was burnt, this was at first supposed to be due to differences in pressure, that is, in the quantity of gas delivered to the burners in the fire box. Automatic pressure regulators were introduced, and the producing companies perfected a system by which the pressures were maintained at a nearly constant figure, yet the same variations were observed. The chemists then began to examine the gas and soon found that it was extremely variable in composition.

As the law of diffusion of gases should effect a thorough mixing of the gases throughout the limits of any gas-pool or area of porous rock, we should naturally expect the gas from each such pool to be of uniform composition. Those who uphold the hypothesis of continuous manufacture underground, quote this variation in composition as one of the strongest arguments in support of the theory, and as yet the geologists familiar with the phenomena of natural gas, who almost without exception have discarded this theory as untrue, have not furnished any explanation of this phenomenon. Two of our most noted scientists versed in the chemistry and geology of natural gas, and disbelieving any theory of continuous production (*paripasu* with consumption), have been disposed to explain this variability by asserting that the law of diffusion may become inoperative in gases under great pressure. As the diffusion of gases results from molecular activity and as this cannot be destroyed or suppressed by pressure, and as it has never been shown that any of the laws of matter may be annihilated, this assertion appears to me to be entirely without support.

It seems to me entirely possible to account for the phenomena without doing violence to any natural law, and to explain how almost any and every possible variation in the composition of natural gas may, if indeed it must not, occur in the gas as yielded by the wells, while the gas throughout the porous area is of uniform composition. The first four of the following analyses were made from gas taken from the same well at different times. The remaining analyses are of wells in different districts.

		1	2	3	4	5	6	7	8	9	10
Carbonic acid,	CO_2	.80	.60	—	.40	.34	.35	.66	2.28	—	.30
Carbonic oxide,	CO	1.00	.80	.58	.40	trace	.26	trace	—	1.00	.60
Hydrogen,	H	20.02	26.16	29.03	35.92	6.10	4.79	13.50	22.50	9.64	14.45
Marsh gas,	CH_4	72.18	65.25	60.70	49.58	75.44	89.65	80.11	60.37	57.85	75.16
Ethane,	C_2H_6	3.60	5.50	7.92	12.30	18.12	4.39	5.72	6.80	5.20	4.80
Propane,	C_3H_8	—	—	—	—	trace	trace	—	—	—	—
Nitrogen,	N	—	—	—	—	—	—	—	7.32	23.41	2.89
Oxygen	O	1.10	.80	.78	.80	—	—	—	.83	2.10	1.20
Illuminating hydrocarbons		.70	.80	.98	.60	—	.56	—	—	.80	.60
Ratio, C to H (weight)		2.72	2.59	2.64	2.59	3.08	3.00	2.88	2.70	2.91	2.84

1, 2, 3, 4. From well supplying Edgar Thompson's Steel Works, by S. A. Ford.
5. Burns well, Butler Co., Pa., by Sadtler.
6. Luckburg well, Armstrong Co., Pa., by Sadtler.
7. Harvey well, Butler Co., Pa., by Sadtler.
8. Cherry Tree well, Indiana Co., Pa., by Sadtler. Small flow through fresh water.
9, 10. Two wells near East Liberty, Allegheny Co., Pa., by S. A. Ford.

The first four analyses show marked variations in hydrogen and ethane. In the gas from the well near Greensburg from which the Cambria Iron Company is to get its supply, Mr. John Fulton informs me that nitrogen is contained in considerable quantity and that it is subject to marked and rapid variations.

All rocks are traversed by cleavage joints and fissures. They may be seen in every quarry, in every railroad cut, tunnel and mine. The rocks of western Pennsylvania are no exception, but the fact that gas exists under great pressure in the porous rocks, is sufficient evidence that these cleavage joints are sealed with a luting of clay and perhaps calcareous material from percolating water, and the fact that the waters do not now percolate from the surface to a greater depth than 300 to 500 feet, is evidence that these narrow crevices are impervious below that depth. The word crevice or fissure is not exactly applicable to many of these openings which are merely joints or cleavage planes, and in a few cases only do they have a width entitling them to be termed crevices or fissures.

If these joints in the rocks above the gas sands are luted with clay or calcareous material, then we have every reason to believe that the cleavage joints of the gas rock itself are also partially closed by similar material, and we may therefore conclude that every gas area is divided into many subdivisions by diaphragms

of clay or calcareous material, through which the gas must diffuse in passing to the well. As the rate of diffusion of gases through porous diaphragms is inversely as the square root of their densities, the gases will diffuse in ratios proportional the following figures:

		Density.	Rate of Diffusion.
Hydrogen	H	1.	1.
Marsh Gas	CH_4	7.985	$\frac{1}{2.82}$
Ethane	C_2H_6	14.97	$\frac{1}{3.87}$
Nitrogen	N	14.01	$\frac{1}{3.74}$

If the diffusion is from an enclosed area the hydrogen percentage will be largely increased and the percentages of the other gases decreased. If the diffusion is through a plane along which a current of gas is constantly flowing to find its way by a circuitous route to the well, the diffused gas will contain a still larger percentage of hydrogen, and nearly equal percentages of marsh gas, ethane and nitrogen. If the diaphragm of clay or calcareous material permits transfusion as well as diffusion, we will have still different percentages.

Again, the gas dissolved and held by salt water contains less hydrogen, nitrogen and marsh gas and more ethane than the free gas. Gas given off from the salt water as the pressure diminishes will therefore constitute another variety. If this gas diffuses through a diaphragm on its way to the well, the diffused gas will have a composition dissimilar to any of the mixtures already described, being lower in nitrogen. If this gas flows past a diaphragm while diffusing through it, the diffused gas will contain nearly all the hydrogen, nitrogen and ethane, and the gas flowing past and around the diaphragm will consist almost entirely of marsh gas.

Hence we have the following varieties:

1. Normal mixture of gas.
2. Gas diffused through diaphragm.
3. Gas left behind diaphragm.
4. Gas diffused through diaphragm while flowing past it.
5. Gas flowing past diaphragm, not diffused.
6. Gas from salt water.

7. Gas from salt water, diffused through diaphragm.
8. Gas from salt water, left behind diaphragm.
9. Gas from salt water, diffused while flowing past diaphragm.
10. Gas from salt water, flowing past diaphragm not diffused.

And in addition to these varieties we may have an infinite number of minor variations resulting from the combined action of diffusion and varying rates of transfusion, and from mixtures of these variations with the normal gas mixture, we can readily conceive a well so located with reference to a salt water area and to a number of cleavage joint diaphragms, that the mixture of gases flowing into it from different directions would be subject to such constant changes, that uniformity of composition even for short periods would be exceptional and variability the rule.

The solubility of these gases in salt water is not accurately known. The following co-efficients of solubility (by volume) in fresh water for a temperature of 20°C. (68°F.) were calculated from the formulæ given by Roscoe and Schorlemmer.*

H	Hydrogen	.01930	1.93 per cent.
CH_4	Marsh Gas	.03449	3.45 " "
C_2H_6	Ethane	.049	4.90 " "
N	Nitrogen	.018	1.80 " "

By *Dalton's law of partial pressures* the composition of the dissolved gas is found by multiplying the percentage of each gas by its co-efficient of solubility, and dividing each product by the sum of all the products, the results showing the percentage of each gas in the mixture.

The influence of unequal pressures underground caused by the unequal action of several wells, drawing gas from the same rock, and the movements of salt water through the rock will sufficiently account for varying flows of gas towards any one well from different directions. Under such conditions it is evident that more abrupt changes in composition would occur than in the case of a single well, drawing gas from a pool in which water movement could not occur, for in this case the gas flowing towards the well from each direction would maintain a constant ratio to the total

* Organic Chemistry, Vols. I. and III., Pt. 1.

flow, and the resulting mixture in the well would remain more nearly constant in composition, except as the mixture coming from any one direction might become exhausted (or slowly change by diffusion) and be replaced by the gas left behind a diaphragm, through which the first mixture had diffused.

XXVI.

NOTES UPON THE EARLY HISTORY OF THE EMPLOYMENT OF WATER POWER FOR SUPPLYING THE CITY WITH WATER, AND THE BUILDING AND RE-BUILDING OF THE DAM AT FAIRMOUNT.

By Frederic Graff, Active Member of the Club.

Read May 1st, 1886.

The earliest official publication referring to the use of water-power for the supply of Philadelphia with water, is contained in a report made by Messrs. John Davis and Frederick Graff, Dec. 18th, 1811, in pursuance of a resolution passed by Councils, Oct. 24th, 1811. After reporting upon the bad condition and inadequacy of the steam works then in use, at Chestnut Street, on the Schuylkill, and at Centre Square, they consider the propriety of building new steam works on the Schuylkill at the Upper Ferry Bridge, and thereby supplying water to a reservoir to be built on "Morris' Hill," now Fairmount. They take up the question of the use of water power, and use the following language, viz:

"With respect to the waters of the Schuylkill at the falls, it appears by the dam erected to supply a mill now built at that place, there is only four feet six inches fall above tide water, there is likewise a fall of about two feet from the falls, to the tail race of W. Robeson's Mill, or the mouth of the Wissahickon Creek, making the whole head and fall about six feet six inches, which fall could be obtained by building a dam across the Schuylkill, above the bridge. There is certainly water, and power enough at this place to supply the city with water, if no impediments ever oc-

curred to prevent the operation of the machinery and works, but the certainty of freshets, which so frequently happen in the river Schuylkill, would render such works nearly as uncertain as the steam engines."

"From satisfactory information obtained relative to the quantity of water flowing from the Wissahickon Creek, at W. Robeson's mill, it appears that in the driest part of the season the stream produces about 10,000 gallons of water per minute, equal to about 14,000,000 gallons every twenty-four hours.

"To employ this stream for the purpose of watering the city, the best mode that appears practicable, would be to dig a race, or canal from Robeson's mill dam, to the Falls of Schuylkill, to erect suitable buildings and machinery at the foot of Sims's Hill (now North Laurel Hill), the summit of which was stated to be 100 feet above high tide and to deliver and supply into two large reservoirs, on said hill, as much water as is requisite to supply the city, and to lay a cast iron pipe of eighteen inches diameter and connect the same with the distributing chest at Centre Square.

"There is no manner of doubt respecting the sufficiency of the Wissahickon stream, to give an ample supply of water both to the works and machinery, and deliver from three to four millions of gallons of water in twenty-four hours, to such height on the hill as will produce the same quantity at the Centre Square, the whole head and fall, from the mill dam to high water mark below the falls, is nearly thirty feet, which constitutes a power amply sufficient for the above purpose. The sum necessary to carry this plan into operation is certainly very considerable, but if it was executed in a permanent simple way, it would perhaps in the end be the best manner of supplying the city with water."

The amount they estimated for the whole work was $359,718.55 and the probable annual expense for repairs of the works and attendance $1200.

They say further. "If the canal already commenced should ever be completed, (the canal referred to was the 'Union'), and it is found that a portion of its waters could be spared for the use of watering the city, a water machinery could be erected near to 'Morris' Hill' (now Fairmount) to pump or elevate the necessary quantity of water into reservoirs constructed on the hill."

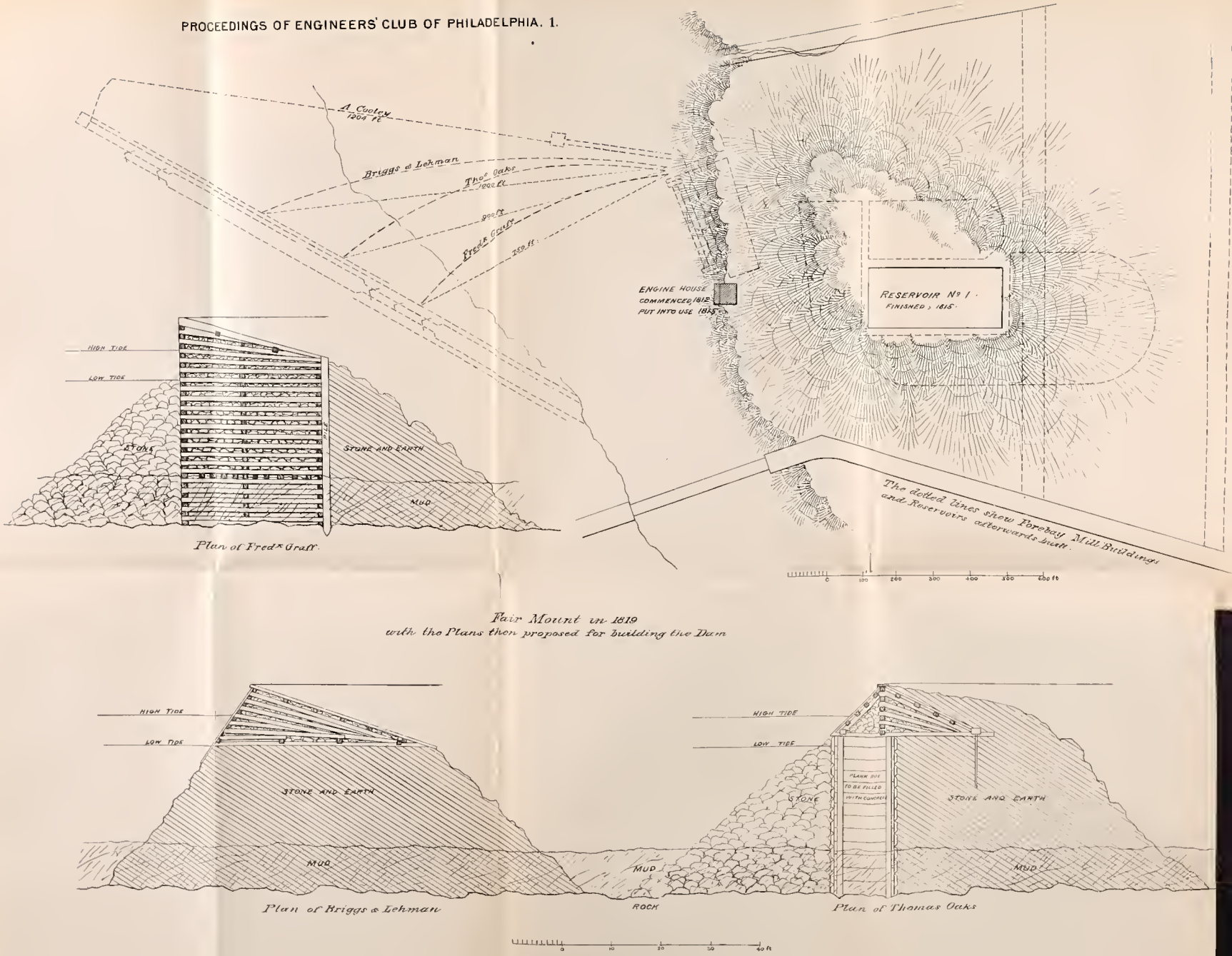
An estimate was also made but not published in the report, upon the plan of purchasing the mills and raising Robeson's Dam, which was at the mouth of the Wissahickon, fifteen feet higher than it then was, and turn the water of the Wissahickon into the canal, which was to be completed to the foot of Morris' Hill (now Fairmount), a distance estimated to be four miles, and there to erect machinery to pump the water into a reservoir on the Hill, from which pipes were to carry it to the distributing chest at Centre Square. Later on the water was conveyed from the reservoir at Fairmount to the distributing chest above referred to, by six lines of wooden pipes. The distributing chest was a cast-iron box into which these lines of logs delivered their water and from which wooden pipes carried it to and down Market and Chestnut Streets.

The estimated cost of accomplishing this work was $370,249.64.

The plan of erecting an engine house, steam engines, and a reservoir on Morris Hill was the one adopted as designed and carried out by Frederick Graff. These works were commenced Aug. 1st, 1812, and supplied the city from Sep. 7th, 1815, to July 1st, 1822, when the supply was commenced from the first water wheel and pump at Fairmount.

Feb. 5th, 1819, the "Watering Committee" made a report in which the following words occur: "The constant and great expense attending steam engines, and the vexation occasioned by repeated accidents, have always been present to the watering committee, who have ever thought water power should be resorted to, if practicable. The present committee have been fully alive to the importance of the subject; and their desire of accomplishing it more and more excited, by the success of the improvement of the Schuylkill by dams and locks, which suggested the practicability of erecting a dam and water works near Fairmount."

At that time there was but little experience in building dams except upon very small mill streams. The committee asked for plans and estimates for a dam and the necessary lock, and such were submitted by Thomas Oakes, Messrs. Lehman and Briggs, Mr. Lewis Wernwag, who had built the bridge at Fairmount, Mr. Frederick Graff, the engineer of the works, and Mr. Ariel Cooley.


A. Cooley
1204 ft
Briggs & Lehman
Thos Oaks
1004 ft
900 ft
Fredk Graff
759 ft
ENGINE HOUSE
COMMENCED 1812
PUT INTO USE 1815
RESERVOIR No 1
FINISHED 1815
The dotted lines show Forebay Mill Buildings and Reservoirs afterwards built.
HIGH TIDE
LOW TIDE
STONE
STONE AND EARTH
MUD
Plan of Fredk Graff.
Fair Mount in 1819
with the Plans then proposed for building the Dam
HIGH TIDE
LOW TIDE
STONE AND EARTH
MUD
Plan of Briggs & Lehman
ROCK
HIGH TIDE
LOW TIDE
PLANK BOX TO BE FILLED WITH CONCRETE
STONE
STONE AND EARTH
MUD
Plan of Thomas Oaks

I herewith call your attention to a drawing copied from the originals, formerly in the office of the Water Department, combined on one sheet, of the sections and plans for the dam, as proposed by all the above named, except Mr. Wernwag. No material for his plan could be found at the date when the drawing was made.

All the plans, except that of Mr. Cooley, were upon the arched form, the chord line varying from 720 feet, that of Mr. Wernwag, to 1000 feet, that of Messrs. Briggs and Lehman.

The plan proposed by Mr. Graff was for substantial framed wooden cribs, sunk through the mud in the deep water to the rock bottom, sheet piled at the back, and re-enforced by rip-rap of stone in front and stone and earth at the back.

Mr. Wernwag's was somewhat similar, but without the sheet pile, or rip-rap in front.

Mr. Oaks dam was to be formed by a planked box or open coffer dam from about low tide to the bottom of the river. This was intended to have been about 12 feet wide up and down stream, and in deep water would have been about thirty feet deep—filled with what was termed "shingle grouting." Upon this was to have been built a framed timber dam, extending about 35 feet up stream, filled with stone, and decked with plank on up and down stream faces, the whole rip-rapped with stone back and front.

Messrs. Brigg's and Lehman's plan was for a pile of earth and stone from low tide to the bottom of the river, about thirty feet deep; upon this was to have been built a framed timber dam, with a triangular section, and base of about 45 feet, filled with stone and decked back and front.

All these would have to be sunk through about eleven feet of mud in the deepest part of the river to solid rock.

Mr. Wernwag's plan contemplated putting the canal upon the east side of the river, an extention of the present forebay of the works, which would of course, have been very objectionable and detrimental to the purity of the water supply, on account of the traffic carried on through the forebay, to reach the canal.

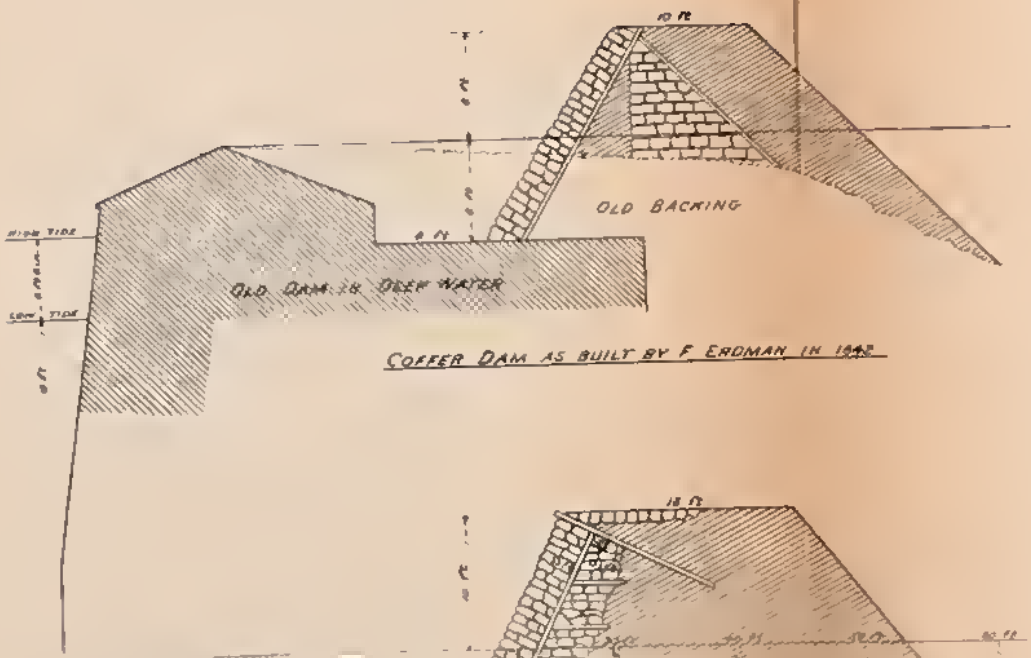
Mr. Cooley, who had more experience in such matters, took the ground that the overfall of the dam should be made as long as convenient to allow surface for the freshets in the river, about

which he had obtained experience in building a dam at Flat Rock (now Manayunk), for the Schuylkill Navigation Company. He was an eccentric person, as the following extract from his reply to a request for his estimate for the cost to erect the dam, will serve to show. He says: "This vast work cannot be effected and completed in manner and form as it ought to be, so as to render the whole work perfectly safe and secure, and so as to fully answer all the purposes intended, 'short of a heap of cash.' I think you can find a man that will be willing to undertake said work, and find surety for its accomplishment and safety, for one hundred and fifty thousand dollars; and after the subject is fully detailed, perhaps a less sum may answer. If you, gentlemen, shall think this partial report worth consideration, and will shortly wait upon me by Committee, or otherwise, I will let you know who that man is."

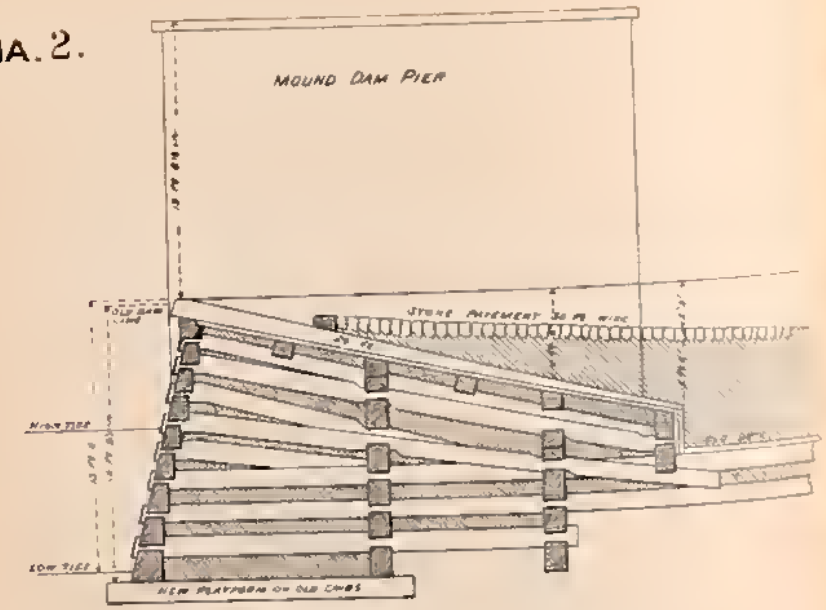
After some negotiation a contract was made with Mr. Cooley for the erection of the dam, locks for the navigation, and the forebay with its head arches for the supply of the wheels and pumps of the water works, for the sum of one hundred and fifty thousand dollars. His plan upon which the dam was built was as follows: The dam was all upon the rock extending diagonally up stream, the overfall was 1204 feet long, with a mound dam, on the east end, of 270 feet; it was made of cribs of round hemlock timber, sunk in the deep water which extended about four hundred and fifty feet in length, to the depth of 31 feet from the comb of the dam; in the deep water the cribs were 40 to 50 feet long up stream, and about 17 feet wide; in shallow water and where they were on rock, dry at low tide, they were from 20 to 25 feet long up stream; they were filled with stone and planked on the up stream ends and top with 3 inch hemlock joists; the whole was backed and covered over the top surface of the dam with stone, rubble and gravel. The section of this dam is shown on drawing No. 2, which also shows the coffer dams used in rebuilding it in 1842–3.

Mr. Cooley's first soundings were made on Feb. 21st, 1819; the building of the dam was commenced April 19th, 1819; the last crib was sunk June 25th, 1821.

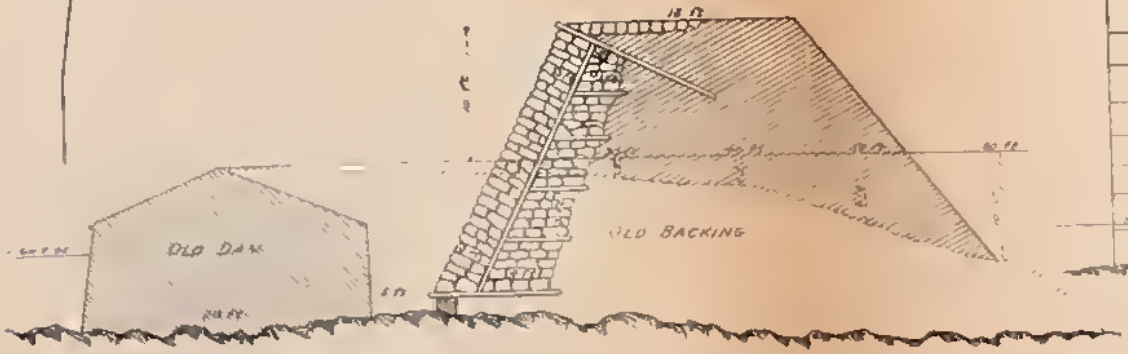
The water flowed over it for the first time July 23d, 1821. The use of the steam engines was discontinued and the whole supply



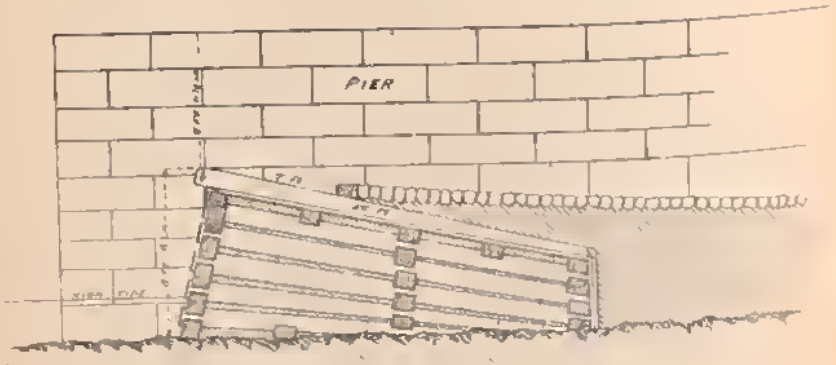
COFFER DAM AS BUILT BY F. ERDMAN IN 1848



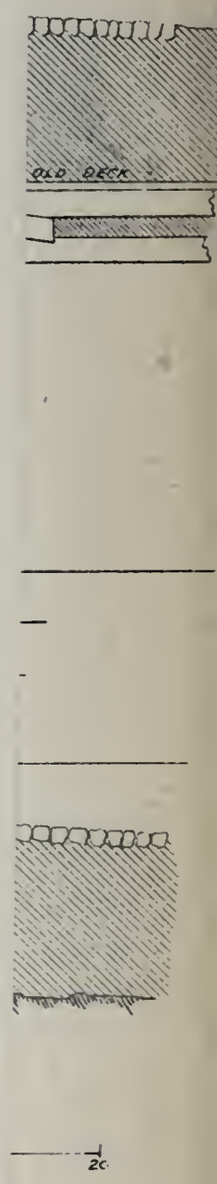
NEW DAM AS BUILT BY F. ERDMAN



COFFER DAM AS BUILT BY M TOWERS IN 1841



NEW DAM AS BUILT BY M TOWERS



use of the steam engines was discontinued and the whole supply

pumped by the water wheels Oct. 25th, 1822. This dam, which was very imperfectly built, mostly of small sized round hemlock logs, put together with two inch wooden "treenails," became so much decayed as to be declared unsafe; and on the 2d of May, 1842, the work of its entire reconstruction, above low water mark, was commenced by day-work, under a general superintendent and a wharf builder, Frederick Graff, Senior, being at the time the Chief Engineer of the Water Department. The old dam was entirely removed from low tide up, the timbers being so much decayed that they were only held in place by the stone filling. The old cribs below low tide having been constantly submerged were sound, and therefore were allowed to remain, after being decked over with heavy white oak logs; upon this the new dam was constructed, as appears in the section marked A, on drawing No. 2—herewith shown.

The whole of the new structure is of white pine, framed and bolted together with wrought iron spikes; after being carefully packed with stone, a deck of white oak was put upon it.

Two sections of coffer dam were used the first year, and six hundred and thirty-five feet of the dam was finished. A severe freshet occurred during the progress of the work, the water rising so high as to commence flowing over the coffer dam; serious disaster involving the cutting off of the entire water supply of the city was only averted by the employment of a large force of men to keep the water from flowing over the top of the coffer, an occurrence which would have proved fatal, and the very fortunate timely decline in the height of the freshet. Six hundred and thirty-five feet of the dam was finished in this year.

In 1843 the work was continued; Mr. Michael Towers, who had much experience in such structures, obtained upon several of the dams of the Schuylkill Navigation, being employed to superintend the work. As the dam of this season was founded entirely upon the rock mostly dry at low tide, it was carried on with less danger and difficulty, the manner of framing the timber work was much improved over that of the previous year, with less waste of strength and material, as is shown in the section marked B, on drawing No. 2. The coffer dam was constructed so that it would have withstood a considerable flow of water over it, which that of the previous year never would have done.

The original Cooley dam, as has been stated, was very roughly constructed, the logs being in some cases very wide apart and poorly secured to each other; the last crib put in June 25th, 1821, was floated into place and never fitted accurately to those adjoining it, the stone filling worked out by the recoil of the water during freshets, its condition became so bad that it was deemed necessary to sink new cribs in the deep water in front of the old dam and carried up to a level a little above low tide. This work was done in 1865—the crib being framed of hemlock and extending thirty feet down stream from the front of the dam, was decked with oak timber ten inches thick. The sinking of this crib appears to have been in the hands of irresponsible contractors who finally abandoned the work; during its progress several freshets occurred, and in consequence it could not be entirely relied upon, subsequently when the present dam was built, it was considered safest to sink another crib in front of it.

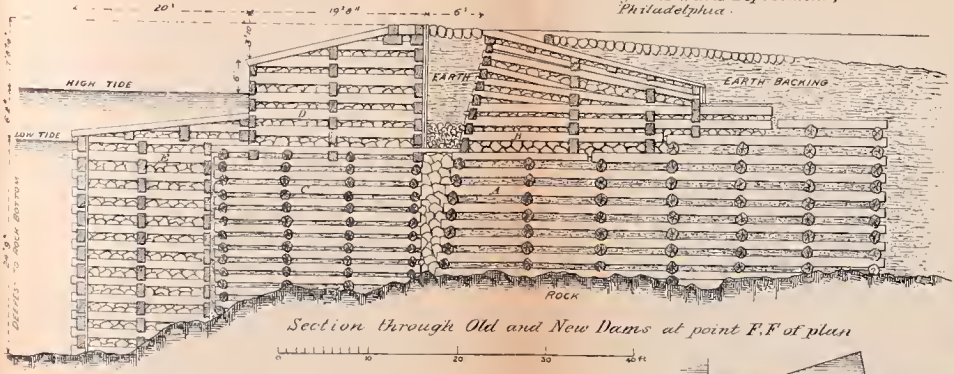
The last dam was commenced June 1st, 1872 (the writer being at the time Chief Engineer of the Water Department), under the general superintendence of Robert W. Bowers. It is built in front of the old one, is upon the rock at the west end and upon the crib that was sunk in 1865, at the east end. At the extreme eastern end a crib of solid timber was sunk, upon which was built a stone pier, forming an abutment for the new dam. About forty feet of the new work remained unfinished at the end of the summer of 1872. The work was completed under another head of department and superintendent in the next season, without any material change in the plan of the previous year.

The drawing (herewith No. 3) shows a section of all the dams, as they now exist, as well as their ground plans. The form of overfall of the last dam, it will be seen, is an improvement over those previously built, as, by this form, floating timber and other matter is projected forcibly away from the face of the work, and does not return, by recoil, against it, as was the case with the previous section

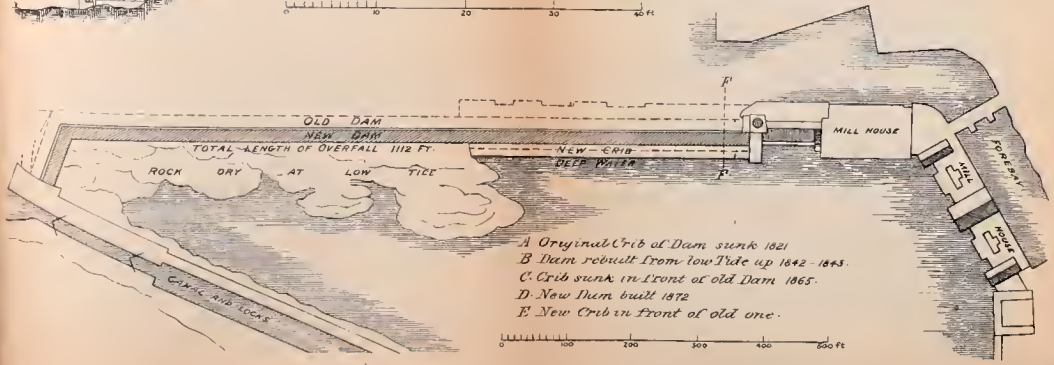
In 1871, efforts were made to obtain appropriations for building a stone dam, instead of that built of timber in 1872; but the sum estimated to do this was considered too high, and for that and for other reasons the project was abandoned.

Plan and Section of New Dam built at Fairmount 1872

Frederic Graff
Chief Engineer Water Department,
Philadelphia.



Section through Old and New Dams at point F.F of plan



XXVII.

CALORIMETRIC TESTS OF BOILERS.

By J. E. Codman, Active Member of the Club.

Read June 5th, 1886.

Tests, for the quality of steam furnished by three different forms of boilers in common use in Philadelphia, were made, for the purpose of obtaining data to be used in the selection of additional boiler capacity.

The apparatus used for determining the quality of steam was a wooden barrel, large enough to contain about 230 lbs. of water, constructed for the purpose, the depth being considerably more in proportion to the diameter than usual. The steam-pipe was carried to the bottom of the barrel, and a number of small holes drilled in the side, the end being plugged up. A side attachment was made, by which the steam could be blown through the pipe, before turning it into the barrel. The barrel was placed on a scale weighing to $\frac{1}{4}$ ounces, and 200 lbs. of water and 10 lbs. of steam were used.

The temperature was taken with a Centigrade thermometer, graduated to $\frac{1}{10}$ degree. An observation was taken every fifteen minutes, and the condition of the fires, running of the engine, and other notes were made at the same time. It was found that the loss from radiation of the mixture was inconsiderable, as the temperature did not fall more than $\frac{3}{10}$ of a degree Centigrade in five or six minutes.

The first series of tests were made on the plain cylinder boilers, 30 ft. long and $4\frac{1}{2}$ ft. in diameter, to the bottom of which were attached two mud-drums, 22 ft. long and 28 in. in diameter. Boilers and mud-drums were set in brick-work and externally fired. The quality of steam obtained from these boilers varied greatly according to the condition of the fires and height of the water in the boilers. The greatest per cent. of moisture obtained was 17 per cent., with fresh fires, and the water above the average height; pressure in the steam-guage increasing, reducing the steam space 30 per cent.; steam escaping freely from the safety-

valves, besides what was required to run two Worthington engines, pumping five and seven and a half million gallons per 24 hours. The least amount, 1.6 per cent., was found when the water was low in the guages, and the maximum amount of steam space was available for storage; steam pressure falling. Steam for the samples was taken from the side of the main steam-pipe, leading to the engine through an $1\frac{1}{4}$ inch valve, and connections reduced to $\frac{3}{4}$ inch about 2 ft. from the steam-pipe, and leading thence to the barrel. The pipe was covered with felt, to reduce the loss of temperature from radiation to a minimum.

The second series of tests were made on what are commonly called the double-deck form of boilers. The lower cylinder was 6 ft. diameter, 12 ft. long, containing ninety-two four-inch tubes. The upper cylinder 4 ft. diameter, 13 ft. long, connected to the lower cylinder by three necks $14\frac{1}{2}$ in. diameter, 9 in. long. Boilers and drums set in brick-work and externally fired. The heat and flame passing under the lower cylinder and through the tubes to the front of the boiler, returning under the upper cylinder to the stacks.

The water is usually carried high enough to about half fill the upper cylinder. This arrangement generally produces very moist steam, especially if the boilers are forced to any extent. The water-line in the boilers under observation was arranged so that the maximum height in the upper cylinder was 14 in., and the minimum 3 in., as measured from the bottom of the cylinder, making the upper cylinder practically a super-heater.

Samples of steam for the tests were taken out of the 14 inch main steam-pipe leading to the engine, about 60 ft. from the boilers. The attachment for samples of steam was made with a $1\frac{1}{2}$ in. pipe, about 12 in. long, and cut in half longitudinally, and tapped into the side of the steam-pipe, and carried inside, so as to nearly reach across the pipe.

An $1\frac{1}{2}$ in. stop-valve was placed in this pipe, about 8 in. from the outside of the main steam-pipe. Beyond this the pipe was reduced to $\frac{1}{2}$ in. diameter, and continued to the barrel. Tests were made every fifteen minutes during the day. And a sufficient number were taken under the varying conditions of cleaning fires, high and low water, and high and low steam, to give a fair

sample of the average quality of the steam furnished in the ordinary working of the boiler.

Steam was used to supply the rotative compound 20 million gallon engine, cutting off steam at about ½ stroke, and pumping at the rate of about 16 million gallons per day, 134 ft. high. At the time the tests were made, steam from these boilers was used for no other purpose, except to supply donkey pump feeding boilers. The steam from these boilers was found to vary from 10 per cent. to 2 per cent. Varying as the water was high or low in the upper cylinder, and the steam rising or falling.

It was noted that in no case was the change of condition in the boiler followed immediately by a change in the quality of the steam; an interval of from 30 to 45 minutes elapsing before the steam changed. This was no doubt due to the fact that the boiler capacity was far in excess of the amount required to run the engine.

The third series of tests were made on the Marine tubular boilers, 10 ft. 10 in. long, 11 ft. 6 in. diameter, containing two corrugated furnace flues and 188—3 in. tubes, with one steam drum 3 ft. 6 in. diameter, 12 ft. 6 in. long, connected to two boilers. These boilers are internally fired, and so arranged that the escaping gases pass off through the tubes, and under the drum before entering the stack. Ten boilers running and supplying steam for two 15 million gallon Worthington pumps.

Steam for samples was taken from the main steam-pipe, about 16 ft. from the boilers, connection was made with a 2 inch pipe and stop-valve. Reduced to ½ in. about 2 ft. from the main pipe and continued to the barrel. Steam from these boilers was found to show but slight variation, ranging from 9 to 6 per cent. of moisture.

The average of all the tests for each kind of boiler was found to be for the

Cylinder, . . .	4.05 per cent.
Double-decked tubular,	4.66 " "
Marine tubular . .	6.91 " "

Comparing the results as given in the annexed table, it is found that the cylinder boilers, driven to their full capacity, still furnished a fair sample of steam; while the double-deck

boiler, doing only one-third capacity, furnished an average quality of steam; and the Marine boilers, doing nearly the full capacity, furnished steam containing $2\frac{1}{4}$ per cent. more moisture than either of the other two furnished.

Comparing with the evaporative efficiency of 5 lbs. of water per pound of coal, at given pressure and temperature for the double-deck, and 6.3 lbs. for the Marine boilers; and allowing for the $2\frac{1}{4}$ per cent. more of moisture in the steam, the Marine boilers will give 24 per cent. better results than the double-deck.

Comparing this with the amount of work performed, it is found the Marine boilers were doing 43 per cent. more work, showing an advantage in favor of the internally fired Marine boilers, both in evaporative efficiency and quantity of steam furnished. In comparing the amount of steam furnished by each kind of boiler, the steam was computed from the indicator cards, for double-deck and Marine boilers, taken from the engines running at the time the tests were made. This therefore accounts for the small figure of evaporation given in the table, as only about 75 per cent. of the steam can be accounted for by the indicator card. For the cylinder boilers it is from the actual amount of water weighed and pumped into the boilers. Therefore no comparison on the same basis can be made with the other boilers.

TABLE SHOWING RESULTS OF CALORIMETRIC TESTS OF THREE DIFFERENT FORMS OF BOILERS.

[1]Description of boilers	MARINE TUBULAR			DOUBLE-DECK TUBULAR			CYLINDER
[2]Number of boilers in use . . .	10			5			8
[3]Diameter of boilers in feet . . .	11½			6			4½
[4]Number of tubes in each boiler	188 (3″)			92 (4″)			. . .
[5]Square feet of fire surface (total)	1360 (8.7 per cent.)			720 (10.5 per cent.)			4000
[6] " " " tube " "	14150			6135			. . .
[7]Total heating surface	15510			6855			4000
	May, 1886.			April, 1886.			F'b.'86
[8]Date of tests	3d	5th	6th	20th	21st	22d	10th
[9]Number of tests each day . . .	9	8	18	16	16	6	16
[10]Highest steam pressure by guage	58	56	58	58	55	56	43
[11]Lowest " " " "	53	53	54	47	51	51	40
[12]Average " " " "	56	54½	55	53½	53	54	41½
[13]Height of water in upper drum	. . .	. . .	. . .	12 to 5	12 to 8	11 to 9	. . .
[14]Average temperature of feed water to boilers	120 F.	120	120	140	140	140	113¼
[15]Average temperature of feed condensing water	66	70	70	68	69	69	43
[16]Average temperature of external air	60	72	61	65	54	66	40.8
[17]Pounds of steam taken from boiler per hour, measured from indicator card	. . .	19.980	20.880	. . .	6350	. . .	. . .
[18]Pounds of steam from boiler per hour, measured by water actually weighed and pumped into boilers	. . .	. . .	. . .	. . .	. . .	. . .	19.657
[19]Pounds of steam per sq. foot of heating surface (per hour) .	. . .	1.29	1.35	. . .	.92	. . .	4.9
[20]Horse power developed from indicator card	. . .	832	889	. . .	391	. . .	. . .
[21]Pounds of steam per horse power per hour	. . .	24	23½	. . .	16.1	. . .	. . .
[22]Pounds of coal burned per hour	. . .	3170	3358	. . .	1270	. . .	3063
[23]Pounds of coal per sq. ft. of grate surface per hour	. . .	7.54	8.00	. . .	7.5	. . .	15.32
[24]Pounds of water evaporated per pound of coal from actual pressure and temperature . .	. . .	6.3	6.2	. . .	5.00	. . .	6.15
[25]Average per cent. of moisture in the steam for each day . . .	7.3	6.05	7.4	5.75	4.62	3.62	4.05
[26]Average per cent of moisture in three days	. . .	6.91	. . .	. . .	4.66	. . .	4.05

COMPARISON OF RESULTS BETWEEN MARINE AND DOUBLE-DECK BOILERS.

[27]Difference in favor of double-deck boiler in quality of steam, ... 2.25 per cent.
[28] " " " " Marine boiler in economic evaporation, in lbs., 1.25
[29]Less 25 per cent. for moisture in steam, pounds, ... 1.22
[30]Per cent. in favor of Marine boiler in economic evaporation, ... 24 " "
[31]Difference in favor of Marine boiler in water evaporated per sq. ft. of heating surface in lbs. 0.4 . . . . . 43 " "

NOTE.—Same quality and size of coal used under all the boilers during the tests.

XXVIII.

TAPER OF STEAM JETS.

By George R. Henderson, Active Member of the Club.

Read June 5th, 1886.

A short time ago, I was designing some apparatus, for which it was desirable to know the angle or taper of a jet of steam issuing from a circular orifice.

Information on this subject seems to be very scarce; therefore it was decided to determine the shape of the jet by experiment.

After considering various methods for obtaining a correct outline, we concluded that the easiest, quickest, and most reliable would be to photograph the jet, as it was issuing from the nozzle. This way had several advantages—it could be taken instantaneously between any puffs of wind that would tend to disturb it, and the angle could then easily be measured off directly from the photograph.

A 2″ pipe was led off from the main steam-pipe of the boilers, terminating in a tee and reducer, into which the smaller sizes for the nozzles were screwed, pointing upwards.

The camera was so located that the jet was seen on the ground glass projected upon a sheet-iron stack, painted black, which was about 12 feet in the rear, the camera being about 12 feet in front of the jet. Three sizes were experimented with, $\frac{1}{4}''$, $\frac{1}{2}''$, and $\frac{3}{4}''$ openings. The nozzles were made of gas pipe, a $\frac{1}{4}''$ larger size than the opening, the ends being swedged down to the size, tapered in about $\frac{1}{2}''$ of the length. The pressures were 95 and 145 lbs. per square inch.

The location was tolerably well sheltered from the wind, and the exposures were made when the air was comparatively quiet. As will be noticed in the photographs, the sides of the jet are almost perfectly straight lines. The angle was determined by drawing lines on the prints corresponding with the sides of the cone, bisecting this angle, and then measuring off two ordinates from this centre line, a certain distance (2″) apart. The difference of the ordinates divided by the distance between them (2″), gave the natural tangent of half the angle of the cone.

With $\frac{1}{4}''$ nozzle and 95 lbs. pressure, the half-angle was 11° 19′.

$\frac{1}{2}''$	nozzle,	95	lbs.,	11° 39′
$\frac{3}{4}''$	"	"	"	13° 5′
$\frac{1}{4}''$	"	145	"	12° 4′
$\frac{1}{2}''$	"	"	"	10° 54′
$\frac{3}{4}''$	"	"	"	11° 27′

It will therefore be seen that the greatest difference between any two was little over 2°, the $\frac{3}{4}''$ nozzle at 95 lbs., and the $\frac{1}{2}''$ at 145 lbs., giving the maximum and minimum angles respectively. Inspection of the results also shows that the angle does not seem to vary according to any law relatively either to the pressure or size of nozzles.

Taking the mean of the two extremes, we have an angle of 12°; the *average* half angle of the six experiments gives 11° 44′, or as the tangent of this angle is about .2, we may call the taper of the sides of the cone, 1 in 5.

I would add that I am indebted to Mr. W. E. Hall, Member of the Club, for his assistance in making these experiments.

XXIX.

THE MOVEMENT OF ICE IN THE DELAWARE RIVER.

By Spencer C. McCorkle, Active Member of the Club.

Presented June 19th, 1886.

The following extracts will explain the appearance of this Report in these Proceedings—Sec.

U. S. Coast and Geodetic Survey Office,

Washington, June 10th, 1886.

Mr. F. M. Thorn, Superintendent.

Sir:—I find Mr. McCorkles Ice Report on my table. * * * * *

Mr. McCorkle should, I submit, put his data before the "Engineers' Club" and before any Marine Association that there may be in either of the three states, that so interesting a theme and report may have the benefit of interested discussion.

Very Respectfully
(Signed) Henry Mitchell,
Coast and Geodetic Survey.

U. S. Coast and Geodetic Survey Office,

Washington, June 10th, 1886.

S. C. McCorkle, Assistant C. & G. Survey, Philadelphia, Pa.

Dear Sir:—In a letter of this date referring to your report on the Movements of Ice in the Delaware River, Assistant Henry Mitchell suggests that you be authorized to submit your Report and data obtained by your observations, to the "Engineers' Club of Philadelphia." * * * * * * * * * * * *

You are authorized, as suggested by Assistant Mitchell, to communicate the results of your ice observations to the Engineers' Club. * * * * * * *

Yours Respectfully
(Signed) F. M. Thorn,
Superintendent.

U. S. Coast and Geodetic Survey Sub Office,

Philadelphia, June 26th, 1886.

Mr. Howard Murphy, Sec. and Treas. Engineers' Club, Philadelphia Pa.

Dear Sir:—By authority of the Superintendent of the C. & G. Survey, and at the suggestion of Prof. Henry Mitchell, Assistant C. & G. Survey, I herewith enclose a copy of my Report on the Movement of Ice in Delaware Bay and River during the winter of 1886. I have included in the documents accompanying this report, copies of the letter of the Superintendent, and Prof. Mitchell, and also *abridged* copies of notes in the form of Appendices numbered 1. 2. 3. 4. 6. The originals are at this office.

It is with diffidence that I place before the Club, a report that was not intended for aught but a commencement of a series of observations and for the Superintendent. I have, therefore, to say to any Member of the Club who may chance to look over my report, that I have been trying to solve a very difficult problem and will be truly thankful to any one who will help me on my way.

Yours very truly
Spencer C. McCorkle,
Assistant C. & G. Survey.

Mr. M. F. Thorn,
Superintendent Coast and Geodetic Survey,
Washington, D. C.

Sir:

In accordance with your instructions of January 4th, to "observe movement of ice in the Delaware River," I have to report as follows, viz:

Through Capt. Geo. B. White, U. S. N., and Light-house Inspector Fourth District, I obtained an order from the Light-house Board, instructing the keepers of light-houses to make observations for temperature, and the movement of the ice, during the

months of January, February, and March. I selected the keepers of eleven (11) lights, viz.: Horseshoe Range Beacon, Mouth of Schuylkill do., Billingsport, Schooner Ledge, Cherry Island Flats, Deepwater Point, Finn's Point, New Castle, Reedy Island, Ship John, Cross Ledge, and the keepers of the 14 foot bank light-ship, and Delaware Breakwater. I have received reports from all except the light-ship, which was removed from her station, on account of the ice, too soon after instructions were received to be of use.

Thirteen thermometers were sent to the various light-houses, one of which was broken by accident, at the light-house, and two (2) remain at this office—making fifteen (15) in all, the number for which my requisition was made.

I have also received reports from the masters of the "Winsor" line of steamers, the Philadelphia and Reading R. R. steam colliers, and the Trustees of City Ice-boats.

I shall divide my report into three sections, viz.:

Number One, From Philadelphia to Billingsport.

Number Two, From Billingsport to New Castle.

Number Three, From New Castle to Delaware Breakwater.

(The general opinion is that the most difficulty, by reason of ice, is found in the vicinity of the Horseshoe, Billingsport, and Fort Delaware.)

Section No. One. Philadelphia to Billingsport.

The river was frozen over on the night of January 10th, and the ice continued in the coves and on the shoals until February 14th. There was some little heavy ice in March, but not enough to do any harm. The extreme cold spells were between January 10th and 15th, 23d to 25th—February, from the 3d until the 7th, and on the 27th and 28th—March 1st and 2d.

The extreme cold in the first part of January was a benefit to navigation in one sense, for the ice in the coves, and on the shoals, remained solid, or nearly so, during the entire period of freezing weather, and the channel only was opened by the ice-boats.

Beginning at the head of Petty's Island, my observations go to show that the dike, built last fall by the engineer in charge of

the improvement of the Delaware River, from Fisher's Point in the direction of Petty's Island, had the effect of causing a greater volume of water to flow through the western or Philadelphia channel, and in consequence the river from Five Mile Point down has been less obstructed by ice than at any time within my knowledge. I have conversed with the inhabitants in this vicinity—many of whom agree with me in this opinion.

The river in front of the city has also been less obstructed by ice than usual, possibly owing in part to the conditions above stated, very largely to the powerful ferry-boats; these boats, consisting of four lines, have been enabled to make regular trips with very few exceptions—notably on the 14th of February, when the up-river ice came down, a full account of which will be found in Appendix No. 5.

The Horseshoe has given less trouble than usual, owing to the ice remaining solid in the coves and on the flats. The channel was kept open by the ice-boats, when necessary, and with the exception of a few hours on some days during the ice period, there was very little detention, and then only to steamers of insufficient power, and to vessels that started at the wrong time of the tide. The solid ice in the coves acted as a receiver for much of the floating ice, and the channel was something like a canal in the middle of the river, in which ice floated up and down with the tide, and sometimes was entirely clear.

Between the "Shoe" and Fort Mifflin, including the full front of the Navy Yard at League Island, the channel was generally free, but further down from Fort Mifflin to Tinicum Island, passing Billingsport, it was often badly obstructed, more or less affected by all winds, but a strong northerly wind sends the ice down very fast on the ebb. The prevalence of westerly winds makes the western channels clear. All the eastern channels are more or less obstructed by ice.

Steam power is the *solvent* of the ice problem, and will be until the river is improved. The large steamships had no detention of note—courage, and a strong full-powered steamship care very little for the Delaware ice, but the wooden vessels, notably schooners, were generally laid up during the ice season. I learn that it was more on account of the high price of *towage* than of *ice.*

The tug-boats are too small to tow when there is ice, they have so little beam that after they pass through the ice it closes up in their wake, and the vessels that are being towed have no defence;—what is wanted at this port are two large propeller tow-boats of at least 30 feet beam and full powered. These, taken in connection with the ice-boats, could take care of the navigation of the river. Or the ice-boats could give notice that every day at a certain hour (depending on the tide) they would be ready to convoy a fleet up and down. Many persons besides myself approve of this action.

City Ice-Boat No. 1 rendered efficient service in this section, aided from time to time by Nos. 2 and 3. The ice-boat reports, and the reports of the "Winsor" line of steamships, will be found in the 4to volume accompanying this report. Also report of light-house keepers at Horseshoe Range Beacon, Mouth of Schuylkill Range Beacon, and Billingsport Light, in Appendix No. 3.

Section No. Two. From Billingsport to New Castle.

From Billingsport to Chester seems to be the worst part of this section, owing mostly to the channel being on the eastern side of the river. I have observed that the river below Claymont has been less obstructed by ice than above, although the ice is sometimes very bad between New Castle and Claymont, especially with an easterly wind. *But "the meeting of the waters"* is the main trouble—when the ice is heavy there is always a difficulty at the *last* of the flood and *first* of the ebb. Controlled somewhat by the winds.

The prevailing winds during January, February, and March were northerly and westerly—more of the latter. By glancing at the chart the explanation and effect of the winds is shown better than I can explain it in this paper.

The eastern channel of Cherry Island Flats was but little used, and was generally full of ice.

The ice-harbors at Marcus Hook and New Castle were of great assistance to vessels, especially to the smaller craft; and Ice-Boat No. 2, with headquarters at Marcus Hook, did efficient service.

The report of the ice-boats and light-house keepers at Billings-

port, Schooner Ledge, Cherry Island Flats, and Deep Water Point will throw further light upon this section.

The keeper of Deepwater Light-house saw visions in the night—he saw "ice piled up 20 feet high" in the vicinity of his station, and also "*Icebergs,*" which is considered somewhat remarkable. I confess that I did not see any thing so high, or so deep and wide, but he was always, it is supposed, on the spot, and I—was not.

I noticed less piling of ice than at any previous season.

Section No. Three. From New Castle to Delaware Breakwater.

By glancing at the chart of the river in the vicinity of Fort Delaware, it will at once be seen where the trouble commences and continues; the eastern, or ship channel, being the most obstructed, except when the wind is east, and the obstruction quite often extends to Reedy Island. The light draught steamers use the western channel almost always, while the ocean steamships are compelled to use the eastern channel; but even with the ice at its worst, I have heard of no serious detention to the ocean steamships, or "Winsor" line, except that which was caused by fog or low water. This is the triumph of *power.*

Below Reedy Island there is sometimes a great accumulation of floating ice; on Dan Baker Shoal a good deal of fast ice, and so on down the Bay—whenever and wherever the *tides* meet there is an obstruction—more or less affected by the wind. Some of the steam colliers were in the ice sometimes 24 hours, between Brandywine Light-house and Cross Ledge Light-house, drifting up and down with the tide.

The report of these colliers will be found in Appendix No. 4, and I would most commend the report of Capt. Seth Hand, Jr., master of the "Achilles."

I am quite aware that the extremely low tides of this season were partly caused by the prevailing northerly and westerly winds; but in my opinion, there was another cause. In many parts of the river the ice was solid during the whole period from January 10th to February 14th. Much of the floating ice would lodge under this, and a contraction of the tidal area would be

the result—the bar, instead of being the bottom of the river, would be a little above it, and the volume of the flood much lessened; my opinion is therefore, that during a *partial* blockade of the river by ice, a much less quantity of water was drawn by the tide from the sea than ordinary—a full blockade would be still worse.

I had occasion to refer to this question on a previous occasion when discussing the ice problem. In the winter of 1885, the ice was solid across from Cooper's Point, N. J., to the Kensington water works wharf, on the Philadelphia side. The floating ice on the flood packed under the surface ice until, in some places it almost reached the bottom.

The natural current of the river being small in the winter season, this line of ice might be called the head of the tide, and in my opinion was so, for at least twenty days; of course there was some flow, but it was very small comparatively.

If my conclusions are worthy of attention, I would suggest the importance of tidal observations during a season of ice.

Remarks and Suggestions.

The dike at Fisher's Point, and the contemplated dredging of the bar at Five Mile Point (proposals for which have been invited), will, in my opinion, make a revolution in this part of the river. Already there has been a marked increase in the flow of water through the western channel.

The improvement at the head of Smith's Island, as recommended in my former reports, and I believe every one agrees as to the necessity of an improvement at this point, should be supplemented by a renewal of the dike at the foot of Windmill Island, by the removal of the shoal opposite Greenwich Point piers, and by the *building of a sea wall from Greenwich Point to League Island*, to be constructed about 400 feet inside of the "Pier Line" (adopted by the Harbor Commission) at its middle section. The importance of this last improvement would make a report in itself, and must be left for another time; this much I can say, that the Delaware is a great river,—second only in importance to the Mississippi. The time will come when its banks will be protected, and by so doing the ice troubles will

be much decreased. Thousands of acres of land now unproductive will be brought into use, and a great benefit to navigation will follow. There is at this time, I am told, no better lighted river than the Delaware in the world, and the ranges point to positions of defence of the channel in case of war.

On the New Jersey side of the Horseshoe I am inclined to think that the building of dikes would be violently opposed by the people of that state, and the nearest approach to the solution of that problem that I have seen, is the report of the late Col. I. D. Kurtz, Corps of Engineers, U. S. A., to the Chief of Engineers, in 1872. Col. Kurtz was a distinguished officer of the Engineer Corps, and had given great attention to a solution of the ice problem. An extract from this report will accompany this paper, Appendix No. 1. I would also call your attention to an extract from the report of Assistant Engineer E. A. Gieseler, of November, 1883, which is also appended. (Appendix No. 2.)

Any improvement of the navigation of the river will lessen the difficulties of an ice blockade. I have therefore to include some mention of the contemplated improvements in the river.

A dike soon to be constructed from Hog Island to Maiden Island, is a step in the right direction, as it is almost impossible to improve the Fort Mifflin bar by dredging alone.

The increased current which the dike is expected to create, will, no doubt, in time scour out a greater depth, and I hope will at the same time wash away the "Pier" opposite Fort Mifflin, which has fulfilled its mission, and is, I think, very much in the way of improved navigation. The problem of bringing the course of the flood and ebb tides nearer to each other, is interesting.

Just here I would protest against the habit of depositing the dredged material back into the river, either above or below the cut; this practice seems to me to be a *reductio ad absurdum*, the more so as the banks of the river are generally low, and require filling in.

The shape of the ice-piers might be improved, I think, and not present such shoal creating barriers as at present. It must be borne in mind, however, that I have had very little opportunity of inspecting the currents, or rather the action of the same; and

I am persuaded, that without more tidal and current observations, good results cannot be obtained.

It appears to me, and I am not going outside of the ice question either, that tidal observations should be made for at least one year at Cape Henlopen, Brandywine Light-house, Fourteen Foot Bank Light-house (soon to be completed—October 15th), Cross Ledge, Ship John, Reedy Island, Fort Delaware, Edgemoor, Chester, Navy Yard (League Island), and Gloster Point,—arrangements could, I think, be made with the keepers of these light-houses. The number of stations is large, but the importance of the river is very great. Well connected current observations are also needed very much.

The contemplated improvements by dike on the Bulkhead Shoal, above Fort Delaware, will, no doubt, be an improvement. I strongly oppose the closing of either channel at this point. Col. H. M. Robert, Corps of Engineers, U. S. A., who has charge of the improvements of the Delaware, while availing himself of the experience of his predecessors, will, no doubt, mature a project, which will be a solution of the trouble on Bulkhead and Goose Island Shoals—any improvement will lessen the difficulties of winter navigation.

Important works are projected for improving the river below, including an ice harbor below Reedy Island; but I am not prepared to do more than mention them at this time.

The ice in the lower bay will be always troublesome with light winds and tides; during these periods the ice will remain, but a strong north wind will blow it all out to sea, or on the shoals and in the coves.

The Delaware Breakwater.

This harbor seems to be filling up, and frequent surveys should be made to determine the changes. Certainly the harbor is no longer of as much importance as an ice harbor, as of yore.

The Point (Cape Henlopen) is working to the westward, and unless some steps are taken for the improvement of the harbor—among other things, for preventing the drifting sand, which during southerly gales blows into the harbor in large quantities—its importance will continue to diminish, and it will be only fit for small craft.

Many persons think that the ice-breaker was put in the wrong place, and that it should have been placed on the "Shears." Be that as it may, the shoal is now there to stay, and it would not be surprising, if the "Gap," between the south end of the Breakwater and the Point, should fill up. Such action has taken place at other points on the coast, similarly situated. As this is the only harbor between Sandy Hook and the Chesapeake, it is deserving of more attention, perhaps, than it has received. What effect the closing of the gap between the Breakwater and the ice-breaker would have, remains to be seen.

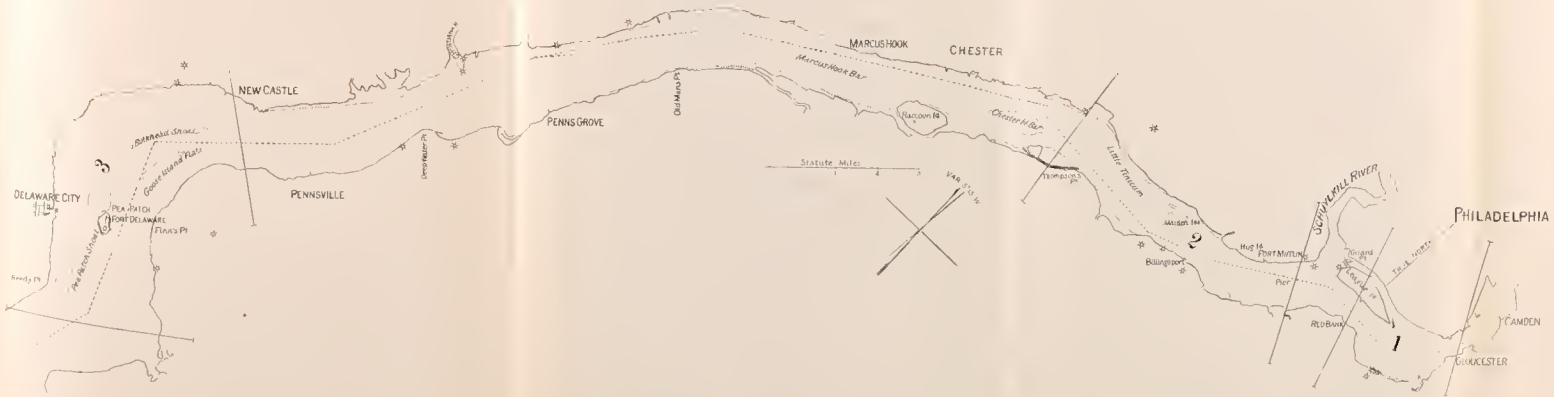
A project has been thought of for dividing the ice-breaker,—leaving spaces through which the sea would flow, but it is doubtful if that would be of any avail, because it is too late. The ice-breaker fails fully to protect the harbor, owing, I suppose, to the shoaling that has taken place. Many vessels were carried to sea by the ice, losing anchors and chains, and some vessels were cut through by the ice while in the harbor, a full account of which will be found in the Appendix No. 5.

Referring to the general improvement of the river, I have long thought that if the amounts spent upon the creeks and branches had been expended upon the main river, much good might have been done. The maxim should be: improve the main river first, then take up the creeks.

I have, as far as possible, tabulated the general results of the season, and they will be found with this report.

I am especially indebted to Capt. Geo. B. White, U. S. N., and Inspector of Lights Fourth District, to Messrs. Henry Winsor & Co., to Capt. J. B. Gallagher, Superintendent Philadelphia and Reading R. R. Steam Colliers, to the Board of Trustees City Ice-Boats, through their Superintendent, Capt. Melville, to Col. H. M. Robert, Corps of Engineers, U. S. A., and Mr. E. A. Gieseler, Assistant Engineer, for valuable information, courtesy, and attention.

By permission of the Board of Trustees, I was allowed to copy the log-books of the City Ice-Boats. The other reports I have copied from the originals sent to me. These records will accompany this report. I desire to keep the originals in my possession, temporarily, for good reasons.


MARCUS HOOK
CHESTER
NEW CASTLE
PENNS GROVE
PENNSVILLE
DELAWARE CITY
PEA PATCH
FORT DELAWARE
Statute Miles
Billingsport
Mud Is.
FORT MIFFLIN
Pier
RED BANK
CAMDEN
GLOUCESTER
SCHUYLKILL RIVER
PHILADELPHIA
3
2
1

temporarily, for good reasons.

Many of the reports are crude, especially in the original, and apparently of not much value, but I think something can be gleaned from them all.

If these observations are to be continued from year to year, it will be desirable to get up something in a book form, for which I would like to confer with Assistant Henry Mitchell, who has given much attention to the study of "the movement of ice" in the Delaware River.

Expenses incurred during season, including cost of thermometers, $38.38.

XXX.

THE INVESTIGATION OF THE MOVEMENT OF FREIGHT AND PASSENGERS IN CITIES.

By Gratz Mordecai, Active Member of the Club,

Read June 19th, 1886.

To be sure I appreciate that it is not necessary in addressing an Engineers' Club to say much about the responsibility of the profession—individually and collectively—to the public. By thought and study you have laid out, designed, and constructed the public works of the country—all its steam appliances and its roads, its waterways, its harbors and its cities, and it would seem that your *methods* of thought, and study, and investigation are destined to control the operation of almost every branch of trade, and to be felt in almost every department of government. Your failures, perhaps, may sometimes be due to politicians or capitalists, but in the end it would seem that the responsibility must very largely rest on you, and that therefore you should be given an active, and, perhaps, a controlling influence in the solution of many of the questions arising in *municipal* government especially.

With this belief I come here to call your attention anew to one of these problems—the movement and distribution of freight and passengers—and to some slight attempts which I have made

entirely unaided to study New York City. I hope you will all be willing to acknowledge that the study of the growth and the public convenience of a city is a legitimate one for an engineer, and that with a view of making a preliminary survey and an approximate estimate of the present methods and cost of handling and distributing freight and passengers, I was not going out of my province when I prepared this map for the purpose.

To be sure you all know that there is a great amount of information about every city scattered in its different public offices, and in those of various corporations and firms, and my desire was first to combine and make all this information intelligible. I knew that every department of the city government was thoroughly acquainted with its specialty, and that the insurance companies, the directory men, and many others, had done what we would call, out in the country, an enormous amount of field work, and that their field books were to a very large extent available. My first step was to get a 400 ft. scale ($1'' = 400'$) map of the city, and I fortunately found one almost exactly to that scale, showing, however, only the streets. With that beginning as a foundation, I converted to the same scale the different maps I found in surrounding cities, in the offices of the railroad companies, of the U. S. Engineers, the Dock Department, and other sources, and in that way I compiled a fairly accurate map to that well approved scale for preliminary work, showing in some detail, yet in a comprehensive way, the streets, the street railroads, the docks, the railroad yards and tracks and facilities, freight houses, city markets, etc.

My next desire was to show something about the freight centres, and the location, growth and concentration of the various trades. With this in view I placed on the original map the house number at the corner of every street (which was given in the directory), and from the business directory, taking the different trades and manufactures separately, I made lists of the numbers at which they were located on every street, and by this means located them on my map, which shows (as you see on tracing vellum) in different colors the location of the retail dealers in food and manufactures, of the wholesale dealers in food and in manufactures, and fixing the location of some of the various trades and freight centres by special marks and numbers.

Appreciating that a city is both a centre of consumption and a centre of distribution, and knowing that an investigation of the movement of freight depends for one thing upon a knowledge of the local consumption, which must depend in part upon its population, I made my estimates of population (permanent and floating) in every ward of the city, and from them made an approximate estimate of the average daily movement of freight for local supply, and incidentally (from the reports of the different city railway companies) of passengers, and some of the approximate figures are given in the accompanying tables, as follows:

AVERAGE DAILY PASSENGER MOVEMENT.

Roads.	Miles of Road.	Passengers Carried.			
		West Side.	East Side.	Cross Town.	Total.
1882.					
Elevated,	32.3	90,000	146,000	———	236,000
Surface,	95.5	156,000	215,000	93,000	464,000
Total,	127.8	246,000	361,000	93,000	700,000
1884.					
Elevated,	32.3	100,000	165,000	———	265,000
Surface,	95.5	169,000	236,000	100,000	505,000
Total,	127.8	269,000	401,000	100,000	770,000

or fully one-half of the permanent population.

APPROXIMATE ESTIMATE OF THE AVERAGE DAILY TONNAGE OF FREIGHT DELIVERED DIRECTLY TO CONSUMERS SOUTH OF 86TH STREET.

	Tons.		
	Food, Clothing, etc.	Coal.	Total.
1885.			
East Side,	1900	4700	6600
West Side,	2200	4500	6700
Total,	4100	9200	13300
1895.			
East Side,	2200	6000	8200
West Side,	3000	6000	9000
Total,	5200	12000	17200

To be sure this movement varies in amount with the seasons, and these figures are only intended to give some idea of the average daily movement of freight for local supply to one destination.

I did all this work simply from my own personal desire to see what could be done, and doing it as I did, without authority, my results, to be sure, are incomplete, and my map hardly more than begun, but I determined to my satisfaction

1. That it is possible to collect and combine in this way information of great value for the growth and prosperity of a city, and for the enlargement of its conveniences for work, such as its docks, its railroads, its markets, its freight houses and other works.

2. That an engineer, by patient investigation and the aid of such a map as that, combined with such detailed maps as the insurance maps, (and other sources I need not mention) could make a most valuable report upon the methods and cost of handling, distributing, storing and selling the necessaries of life, and the principal articles of trade.

3. That the practical uses of such a report would be in the regulation of cities and corporate laws, and in determining the location of public works and improvements.

It is almost a truism to say that the success or failure of a work depends upon its location, and yet corporations not infrequently locate their works by intuition, and the result is a waste of money and continual change, and hence it is generally acknowledged that the study of location is one of the highest and most responsible duties of the engineer. In this connection I will cite two instances which have come under my own observation. The N. Y. West Shore and Buffalo Railway was originally located in 1872, and the men who controlled it at that time, though doubtless wishing to found a great "Trunk Line," assumed a location through Central New York considerably south of its present line. This former location, though not entirely, was partly accepted by the company which built the road in 1881–1883, but through the influence of the new company's Chief Engineer and his assistants the location was radically changed to the North. This change of location, which

lessened the cost and time of building, lowered the height of the summits, shortened the heavy grades, reduced the curves, and in many ways lessened the cost of operation, was presented with such clearness and force by comparative maps, estimates, profiles, and tables, that the effect was irresistible. The Division Engineer, without one particle of pecuniary interest, with simply a desire to tell the whole truth, and to do his professional work honestly and thoroughly and well, carried the day, and the decision was easily made.

The other instance I wish to cite is the location of the elevated railroads in New York City. They were laid out by their promoters, and a public commission appointed for the purpose. How far engineers' methods of investigation entered into fixing their location, I do not know, but I am told by one who should know, that their promoters were a "few thoughtful, bright, progressive men, not engineers, not capitalists, but speculators, who employed engineers, lawyers, legislatures, and aldermen," to do, perhaps, as they were bid.

The result was that these great public necessities were probably laid out by men anxious, doubtless, to do the best they could, but without the responsibility arising even from feelings of professional reputation and regard.

Certainly I cannot help asking myself in looking at that map: Was their work well done? Was the location good? Did they have any complete system in view? A part of the way they have eight tracks, but even with this large number, one object of rapid transit, the running of fast through trains between extreme points, seems in part to be defeated by one double track road on the east ending, 1¼ miles north of the Battery, and another on the west, three miles south of Harlem.

At any rate I cannot help closing with the plea that you do something to prevent the public convenience from being handed over, in an economic and engineering regard, to pecuniarily interested parties, and also to establish the rule that public franchises of all kinds for industrial purposes should be reported on not only by a corporation attorney, but also by a corporation engineer, for no matter how bright and far-seeing and progressive the promoters of new enterprises may be, it would seem that in

public matters they should be officially controlled and aided by your experience and your deliberate methods of study.

XXXI.

A CURIOUS FREAK OF MILD STEEL.

By Samuel T. Wagner, Active Member of the Club.

June 22d, 1886.

I desire to call the attention of those members of the Club who are interested in the use and manufacture of mild steel, to a curious fact developed during the summer of 1884, by the quenching test on a lot of steel angles for the United States Despatch Boat Dolphin, and the Cruisers Boston, Atlanta, and Chicago; and described by Assistant Naval Constructor R. Gatewood, U. S. N., in the report of the Naval Advisory Board, on the mild steel used in the construction of the same vessels. (This report is published with the Report of the Secretary of the Navy for 1885.)

The shape steel for the hulls of the above vessels was rolled by the Phœnix Iron Co. of Philadelphia, Pa., from open-hearth steel blooms, manufactured in Pernot furnaces by the Cambria Iron Company at Johnstown, Pa., and the tensile tests made at Johnstown, by a Government Inspector, from specimen flats rolled from the blooms. The quenching and cold bending tests were made from specimens cut from the finished bars at Phœnixville, the Government tests being made under the direct supervision of Lieut. Gatewood; the writer representing the Phœnix Iron Co., at the time in question.

Referring to the article on Quenching tests in "Instructions issued to Inspectors" by the Naval Advisory Board, we find the following clause which is given in full:

Quenching Test.

"A test piece shall be cut from each angle-plate or beam, and after heating to a cherry red, shall be plunged into water at a

temperature of 82° Farenheit. Thus prepared it must be possible to bend the pieces under a press or hammer so that they shall be doubled around a curve of which the diameter is not more than one and a half times the thickness of the plate tested without presenting any trace of cracking.

"These test pieces must not have the sheared edges rounded off, the only treatment permitted being, taking off the sharpness of the edges with a file."

The majority of the test pieces at Phœnixville were from angles, and were about two inches wide, by ten inches long, sheared from one leg of the angle, thus presenting one rolled, and one sheared edge to be bent. At first all pieces were heated in a smith's forge with blast in a hollow fire, the top being made either of coke or a board covered with pressed coke, thus a few pieces only could be heated at once. After the accident to be related occurred, and the number of pieces to be tested was large, they were always heated in a small heating furnace burning bituminous coal.

Having quite a large number of hurried pieces to prepare upon one occasion, and only one available smith's fire, we determined upon the suggestion of the smith, to heat about sixty pieces on the fire of a small boiler burning anthracite coal, about five or six pieces being heated at a time. The fire door was closed and the pieces were found to heat very uniformly, but it required from fifteen to twenty minutes to bring them to the required temperature, as the fire was very slow. Upon testing, all the pieces failed to pass the requirements, most of them breaking square across with a bright crystalline fracture, and no appreciable reduction of area, some indeed breaking before they had been bent to 90 degrees. Upon making re-tests from the same bars, and bringing them to the proper temperature in the heating furnace in a clear flame, no difficulty was encountered at all, most of the pieces bending until the sides touched.

A reason for this curious behavior was suggested by Mr. Gatewood at the time, on the assumption that the pieces had been subjected to the cementation process of manufacturing steel on a very small scale, and that small amounts of carbon or other hardening elements had been absorbed on the surface of the

steel from impurities in the fire, and had made a hard skin over the entire piece. Upon bending, this thin skin had refused to elongate in the proper proportion, then cracked, and under the same blow that cracked it, had broken open, suddenly revealing the bright crystalline fracture caused by this manner of being broken.

The above incident goes toward showing: 1st. The necessity of careful watching in the preparation of test pieces, as the whole lot would undoubtedly have been condemned, had we not known there was a different method of heating employed in these pieces, and given them a second trial under different, and proper conditions.

2d. The theory advanced by Mr. Gatewood may account for failures in the breaking of expensive steel flangings, more than one of which have occurred in very mysterious ways. The formation of hard spots caused by a flame (heavily charged with impurities from bad fuel) playing on a flanging, together with internal strains caused by unequal expansion and contraction makes a combination much to be dreaded, and points out that careful heating in a clear fire with good fuel may have great influence on the production of sound flangings, or thin forgings.

In conclusion it is advisable to state that the material described had the following physical and chemical properties which represent an average of 133 heats of open hearth steel, viz:

Ultimate Tensile Strength, . .	64020 pounds per sq. in.
Elongation on 8 inches, . . .	25.52 per cent.
Average Carbon, ...	.16⅔ " "
" Manganeese, ...	.44 " "
" Phosphorous (17 heats)	.087 " "

THEODORE BERGNER.

Theodore Bergner, late member of this Society, was born July 1st, 1834, in Crimitzchau, Saxony, and died of heart-disease in Philadelphia, January 5th, 1886.

At the age of sixteen he immigrated to the United States, became an apprentice in the works of Messrs. Sutton & Co., of this city; and subsequently was a member of the firm of Howson & Bergner, Patent Agents. In April, 1857, Mr. Bergner entered the establishment of Messrs. Wm. Sellers & Co. as a draughtsman, and remained with them in that capacity for upwards of eighteen years, during which period he was employed upon much of the most important work undertaken by the firm. In 1867, he visited in their behalf the Paris Exposition, in charge of a very large display of machine tools, and attended to the reception and installation of these machines, sold them to European purchasers, and transacted all the necessary business in the most satisfactory manner. His familiarity with the German and French languages added to his qualifications for such a task; and in 1873, he was sent to the Vienna Exposition, in charge of another large display.

During this visit to Europe he became interested in some mechanical devices for the manufacture of malt,—a special floor for malt kilns and mechanical means of turning and spreading the malt,—and finally concluded to devote his attention exclusively to the introduction of these improvements. He therefore terminated his relations with William Sellers & Co. in May, 1875, and began a general engineering business, with special reference to breweries and malt houses.

Among the larger establishments upon which he was engaged may be mentioned the following breweries and malt houses, which, with their machinery and appurtenances, were built from his drawings and under his supervision, viz.: those of Bemis & McEvoy, Chicago; Neidlinger & Schmidt, New York; P. Lauber, Philadelphia; and the Bergner & Engel Brewing Co., also of this city.

In 1876, Mr. Bergner had charge of the Brewers' Department at the Centennial Exhibition, and displayed there one of his malt-turners in practical operation. In 1878, he visited Europe again to represent Messrs. Hoopes & Townsend, of Philadelphia, at the Paris Exposition of that year.

He was frequently called upon to testify as expert in patent cases, and in connection with his other duties for years carried on a private patent practice of considerable extent. He finally concluded to apply himself exclusively to this vocation, and in connection with J. W. Douglass had just taken the business of the late Henry Baldwin, Jr., when his sudden death put a stop to the career which he had selected, and for which he was doubtless well qualified by his attainments, his training, and his large and varied experience.

As a mechanical draughtsman Mr. Bergner has seldom been equalled, and his drawings are models of what a *constructive* drawing should be, neat, clear, and accurate. He had a very correct eye for beauty of form, and an excellent taste in machine designing. He was not possessed of high mathematical attainments, but had the inventive faculty considerably developed, and excelled in the contrivance of handy and ingenious devices and expedients. Some of these were in the nature of draughting room appliances, such as his pneumatic ink bottle, for preserving ready mixed India ink, his "section-liner," and his drawing-boards. The "section-liner," or "cross-hatcher," is a simple little device, easily attachable to a triangle, and which by pressing upon a small knob or button causes the triangle to move a greater or less distance, as required; the amount of movement being adjusted by a milled nut, and thus parallel lines equally spaced may be drawn at any distance apart.

His drawing-boards have in place of the usual Tee square, a guided straight-edge which may be adjusted to various angles. In the form first designed there were two straight-edges, one above and the other below the board, both projecting beyond the ends of the board, and connected at their extremities, so as to move together; that below the board was attached to a slide which moved in bearings on the lower surface of the board. A graduated arc was provided, so that the inclination of the

straight-edges to the guides was adjustable to any desired amount. This form of board, however, was abandoned by Mr. Bergner for one in which the parallelism of the straight-edge was assured by a system of crossing cords, running over sheaves in the corners of the board; this style of board he introduced in many places, and eventually combined it with a vertical easel, which he exhibited to this Club.

At one time Mr. Bergner invented and patented a very successful machine for cutting cylindrical corks by means of a tubular cutter, with continuous cutting-edge, rotating at a high speed. Among his later inventions were a neat and ingenious counter-shaft for light machines, and a universal counter-hanger of graceful and convenient design.

His inventions, which were numerous, were often suggested by some want which he experienced in pursuing the hobby of the moment. Thus in photography, which he took up in the early days of the art, and in which he acquired considerable skill, he found ample opportunity to exercise his inventive ability. Landscape photography was his specialty, and as the rapid dry plates of to-day were undreamed of by the amateur of that time, he designed for field-work a very handy portable developing tent, which was very light, and packed in a convenient shape for carrying. He also invented a little machine for cutting out photographic prints by means of a pair of dies of sheet metal of the desired shape. The print was pushed face uppermost under the outside die, which appeared as a frame around the picture and enabled it to be moved into the proper position, when a movement of a lever brought a corresponding male die or punch up through the opening and cut out the picture at a stroke. This machine was admirably adapted for small photographs, such as stereoscopic views and *cartes-de-visites*, and is still manufactured and sold for that purpose.

Long before the days of clamp skates, as they are now known, Mr. Bergner devised one which was secured to the foot by means of front and back clamps which grasped two plates, one let into the heel of the shoe and the other under the ball of the foot.

Mr. Bergner was essentially a busy man, and always had some hobby or pastime which absorbed his leisure moments. Pho-

tography, painting, skating, rowing, and horticulture were among these avocations, and in each he attained a large measure of success.

WILFRED LEWIS,
M. R. MUCKLÉ, JR.,
COLEMAN SELLERS, JR., *Chairman.*

QUESTIONS.

No. 3.

May 1st, 1886.

Mr. T. EARL COLLINS offered the following mathematical question: Does a locomotive piston at the end of each stroke, in reversing its direction, come to a stand-still, and if so, can the same be mathematically demonstrated?

Also, would a difference in speed affect the duration of its stationary condition, if such exists?

Mr. Collins suggests: "As the crank pin describes a circle, changing at every point its direction, and therefore having at all times more or less lateral movement, and its movement being continuous, it is argued that the piston can have no moment of rest without the crank pin coming to rest also, supposing perfect joints."

June 5th, 1886.

MR. A. MARICHAL, introduced by the Secretary, presented a mathematical discussion of the above question.

Mr. Marichal claims that it does come to an absolute rest.

TABLES FOR FINDING ORDINATES TO CIRCULAR ARCS.

(CLOSELY APPROXIMATE.)

S. P. MITCHELL, December 19th, 1885.

TABLE I.

Chords.	Prop. Middle Ordinate.	Chords.	Prop. Middle Ordinate.	Chords.	Prop. Middle Ordinate.	Chords.	Prop. Middle Ordinate.	Chords.	Prop. Middle Ordinate.	Chords.	Prop. Middle Ordinate.	Chords.	Prop. Middle Ordinate.
20	1600	32	4096	44	7744	56	12544	68	18496	79	24964	90	32400
21	1764	33	4356	45	8100	57	12996	69	19044	80	25600	91	33124
22	1936	34	4624	46	8464	58	13456	70	19600	81	26244	92	33856
23	2116	35	4900	47	8836	59	13924	71	20164	82	26896	93	34596
24	2304	36	5184	48	9216	60	14400	72	20736	83	27556	94	35344
25	2500	37	5476	49	9604	61	14884	73	21316	84	28224	95	36100
26	2704	38	5776	50	10000	62	15376	74	21904	85	28900	96	36864
27	2916	39	6084	51	10404	63	15876	75	22500	86	29584	97	37636
28	3136	40	6400	52	10816	64	16384	76	23104	87	30276	98	38416
29	3364	41	6724	53	11236	65	16900	77	23716	88	30976	99	39204
30	3600	42	7056	54	11664	66	17424	78	24336	89	31684	100	40000
31	3844	43	7396	55	12100	67	17956						

TABLE II.

Dist. from Cent. of Chord.		Dist. from Cent. of Chord.		Dist. from Cent. of Chord.		Dist. from Cent. of Chord.		Dist. from Cent. of Chord		Dist. from Cent. of Chord.		Dist. from Cent. of Chord.		Dist. from Cent. of Chord.		Dist. from Cent. of Chord.		Dist. from Cent. of Chord.	
1	16	**6**	576	**11**	1936	**16**	4096	**21**	7056	**26**	10816	**31**	15376	**36**	20736	**41**	26896	**46**	33856
.25	25	.25	625	.25	2025	.25	4225	.25	7225	.25	11025	.25	15625	.25	21025	.25	27225	.25	34225
.50	36	.50	676	.50	2116	.50	4356	.50	7396	.50	11236	.50	15876	.50	21316	.50	27556	.50	34596
.75	49	.75	729	.75	2209	.75	4489	.75	7569	.75	11449	.75	16129	.75	21609	.75	27889	.75	34969
2	64	**7**	784	**12**	2304	**17**	4624	**22**	7744	**27**	11664	**32**	16384	**37**	21904	**42**	28224	**47**	35344
.25	81	.25	841	.25	2401	.25	4761	.25	7921	.25	11881	.25	16641	.25	22201	.25	28561	.25	35721
.50	100	.50	900	.50	2500	.50	4900	.50	8100	.50	12100	.50	16900	.50	22500	.50	28900	.50	36100
.75	121	.75	961	.75	2601	.75	5041	.75	8281	.75	12321	.75	17161	.75	22801	.75	29241	.75	36481
3	144	**8**	1024	**13**	2704	**18**	5184	**23**	8464	**28**	12544	**33**	17424	**38**	23104	**43**	29584	**48**	36864
.25	169	.25	1089	.25	2809	.25	5329	.25	8649	.25	12769	.25	17689	.25	23409	.25	29929	.25	37249
.50	196	.50	1156	.50	2916	.50	5476	.50	8836	.50	12996	.50	17956	.50	23716	.50	30276	.50	37636
.75	225	.75	1225	.75	3025	.75	5625	.75	9025	.75	13225	.75	18225	.75	24025	.75	30625	.75	38025
4	256	**9**	1296	**14**	3136	**19**	5776	**24**	9216	**29**	13456	**34**	18496	**39**	24336	**44**	30976	**49**	38416
.25	289	.25	1369	.25	3249	.25	5929	.25	9409	.25	13689	.25	18769	.25	24649	.25	31329	.25	38809
.50	324	.50	1444	.50	3364	.50	6084	.50	9604	.50	13924	.50	19044	.50	24964	.50	31684	.50	39204
.75	361	.75	1521	.75	3481	.75	6241	.75	9801	.75	14161	.75	19321	.75	25281	.75	32041	.75	39601
5	400	**10**	1600	**15**	3600	**20**	6400	**25**	10000	**30**	14400	**35**	19600	**40**	25600	**45**	32400	**50**	40000
.25	441	.25	1681	.25	3721	.25	6561	.25	10201	.25	14641	.25	19881	.25	25921	.25	32761		
.50	484	.50	1764	.50	3844	.50	6724	.50	10404	.50	14884	.50	20164	.50	26244	.50	33124		
.75	529	.75	1849	.75	3969	.75	6889	.75	10609	.75	15129	.75	20449	.75	26569	.75	33489		

Use of the Tables.—If the middle ordinate on the given chord is not known, first calculate it. Then divide the number in Table I under column marked "Proportional Middle Ordinates," and opposite the known length of chord, by the middle ordinate, and set the quotient aside. Then to find ordinates at other points on the chord, take the difference between the "Proportional Middle Ordinate" already found in Table I, and the number in Table II, opposite any desired distance from centre of chord, and divide this difference by the quotient found as above, the quotient will be the ordinate sought.

Example I. On a chord of 90 ft. with a middle ordinate of 2 ft., to find ordinates every 5 ft. on the chord. In Table I opposite 90 we find 32400, which divided by middle ordinate 2 = 16200. Then for the ordinate 5 ft. from the centre, we find from Table II the number 400, then by the rule $\frac{32400-4000}{16200} = 1.975$, and for 10 ft. from the centre $\frac{32400-1600}{16200} = 1.901$, 15 ft. $\frac{32400-3600}{16200} = 1.777$, 20 ft. $\frac{32400-6400}{16200} = 1.605$, 25 ft. $\frac{32400-10000}{16200} = 1.382$, 30 ft. $\frac{32400-14400}{16200} = 1.111$, 35 ft. $\frac{32400-19600}{16200} = 0.790$, 40 ft. $\frac{32400-25600}{16200} = 0.419$.

To find Ordinates on Chords over 100 ft. in length:—

The Tables can only be used directly for chords of 100 ft. and under, but to find ordinates on chords over 100 ft., find from the chords in Table I some even divisor of the given chord, then divide the distances from centre of chord to points where ordinates are desired by the quotient thus obtained, and using the result of this division in Table II proceed as before.

Example II. On a chord of 320 ft., with a middle ordinate of 5, required ordinates at points 40, 80 and 120 ft. from centre of chord. We see that 80 will divide 320 4 times, so using 80 in Table I, the "Proportional Middle Ordinate" is 25600, which divided by middle ordinate 5 = 5120. Now $\frac{320}{80} = 4$, so for ordinate at 40 ft. from centre we have $\frac{40}{4} = 10$, and number opposite 10 in Table II is 1600, so by previous rule we have $\frac{25600-1600}{5120} = 4.987$, at 80 ft. $\frac{80}{4} = 20$, and corresponding number in Table II is 6400, so $\frac{25600-6400}{5120} = 3.75$, at 120 ft. $\frac{120}{4} = 30$, and number in Table II opposite 30 is 14400, so $\frac{25600-14400}{5120} = 2.187$.

TABLE OF SIZES OF CHIMNEYS.

H. K. Lee, June 19th, 1886.

Effective sq. ft.	Diam. of round flue in inches.	Heights of Chimneys.											Side of square flue in inches.
		50 Feet.	60 "	70 "	80 "	90 "	100 "	110 "	125 "	150 "	175 "	200 "	
		Commercial HP of Boiler.											
.97	18	23	25	27									16
1.47	21	35	38	41									19
2.08	24	49	54	58	62								22
2.78	27	65	72	78	83								24
3.58	30	84	92	100	107	113							27
4.48	33		115	125	133	141							30
5.47	36		141	152	163	173	182						32
6.57	39			183	196	208	219						35
7.76	42			216	231	245	258	271					38
10.44	48				311	330	348	365	389				43
13.51	54					427	449	472	503	551			48
16.98	60					536	565	593	602	632	748		54
20.83	66						694	728	776	849	918	981	59
25.08	72						835	876	934	1023	1105	1181	64
29.73	78							1038	1107	1212	1310	1400	70
34.76	84							1214	1294	1418	1531	1637	75
40.19	90								1496	1639	1770	1893	80
46.01	96									1876	2027	2167	86

NOTES AND COMMUNICATIONS.

THE BEHAVIOR OF WATER IN A DOUBLE SIPHON.

Business Meeting, February 20th, 1886.—Dr. H. M. Chance described phenomena experienced in draining a mine by siphons. In the case of a double siphon drawing water from two sumps at different levels, the siphon, upon starting, operated satisfactorily, drawing water from both sumps, but in a few minutes the current in the branch leading to the lower sump reversed, and water was discharged *into* this sump, the main siphon continuing to work as at first. This action seems to be due to the loss of head due to friction, as the water acquires considerable velocity in the discharge by which the efficient head at the lower sump is greatly reduced.

LATHES FOR TURNING STEEL TIRED CAR WHEELS.

Regular Meeting, March 6th, 1886.—Wm. H. Derbyshire described a new double Lathe for Turning Steel Tired Car Wheels, showing the method of holding the axle at four points, so as to give greater steadiness under the cut. The drivers, adjustable in all directions, and a convenient callipering attachment for bringing the wheels to size, were also shown, as well as the cutting tools, which take the whole face of the tire, including the flange, at one operation.

Mr. F. W. Gordon described a Lathe for the same purpose, which resembles in many respects the ordinary double headed wheel lathe. There are two head stocks with face plates, two carriages, etc., for finishing both wheels at the same time. The novel feature claimed for this lathe is the arrangement for supporting the axle on its journals, affording a substantial bearing, close up to the wheels to be turned, and thus permitting heavy cuts and doing true work. The lathe has no live spindles. The face plates revolve in rigid projections from the head stocks. The only duty of the face plates is to revolve the work, and the trueness of the work is said to be in no way dependent on the fit of the face plate bearings. In these projections are substantial chucks, which grip the axle on its journals. The distance from the point of support to the point of cut is thus reduced to a minimum; the journal support permits a much heavier cut than can be taken in centres; the wheel is turned true. The work, he said, can be turned out very rapidly, and when done, is well done.

INTERMITTENT SIPHONS.

Regular Meeting, March 20th, 1886.—Mr. Charles G. Darrach explained the principles involved in the construction of Intermittent Siphons.

He said: The reason of the leakage from intermittent siphons, as usually constructed, is due to two principal causes. The first is, that the vertical dimension of the orifice connecting the two legs of the siphon is made too great, and the head of water in the sealing trap at the end of long leg is overcome before the entire area of the orifice is filled with water.

Second. The partial vacuum produced in the siphon, when the water drops out of it, (after the siphonic action is stopped) is not entirely destroyed, and the water rises

in the short leg above that in the tank and leaks out through the communicating orifice, at the upper bend of the siphon, whereas the air pressure *in* the siphon should be greater than the pressure on the water in the tank.

Mr. Darrach then described an intermittent siphon designed by Mr. Jos. M. Wilson, C.E., Member of the Club, in which these principles were recognized and which answered perfectly the object sought.

Modifications of this siphon, designed for grease traps, sewage or water flush tanks, and for siphon weirs to be used to draw water from the lowest stratum of deep reservoirs without the aid of auxilliary siphons, were described, and the method shown by which the discharge could be made at stated intervals, or the water drawn down to any desired level within the range of atmospheric pressure.

In the siphons described, the short leg of the siphon is formed into an air chamber of sufficient size, to allow for the compression of air produced by the head of water in the sealing trap, and for the loss of air discharged from the long leg before the siphonic action is induced. A small hole (protected by a pipe, carried above the highest water level in the tank, when the siphon is used for grease or sewage) is made in the short leg or air vessel at such a height, that it is exposed when the water level in the flush tank is raised by the back flow from the short leg into the tank. After siphonic action ceases, this hole and pipe continue to admit air to the syphon, and destroy the partial vacuum produced by the water dropping out of both legs of the siphon. By this arrangement the siphon is always recharged with a full supply of air.

Mr. Darrach explained a number of experiments made by him to substantiate the theory.

RECENT STREAM GAUGING FOR THE FUTURE WATER SUPPLY OF PHILADELPHIA.

Regular Meeting, April 17th, 1886.—Mr. H. W. Sanborn made some remarks on this subject, describing the methods used and why they were adopted, illustrated by numerous drawings and photographs, and the automatic recording gauge. The streams gauged were the Perkiomen Creek and tributaries in Montgomery County, the Neshaminy and tributaries and the Tohickon in Bucks County. The original intention was to gauge the minimum flow only, and for that purpose weirs were constructed on eight different streams. They were very substantially built, as they had to withstand the run of ice in the spring of the year. Heavy bed logs were placed at the level of the bed of the stream, and the superstructure built on that. They were made water-tight either by sheeting placed below the bed-log, to rock bottom, or a cement mortar wall. The crests of the weirs were generally about two feet above the beds of the streams, and were made of two-inch oak plank. Gauge boards were placed about five feet above and below the weirs, and connected, by levels, with the same. The one above indicated the depth of water on the crest. The one below was used only in case the weir was submerged by high water. The weirs varied in length from fifteen to seventy feet, according to the width of the stream. The formula used for calculating the flow over the weir was the one by Fteley & Stearns, of the American Society of Civil Engineers. Stream gauge stations were established near the weirs. Readings were taken there at the same time that they were at the weirs. When a sufficient number of readings, at various heights, were made, a "curve of flow" was plotted by a comparison of the two. Then, when the crests of the weirs were removed

for the winter, the flow was found by referring the stream gauge readings to the "curve of flow."

The great fluctuation in the flow of the streams, caused by the great number of mills on them, necessitated a great many observations at the weirs to get a correct gauging. This difficulty was overcome by the use of automatic gauges. They were run by clock-work, and drew a line on a roll of paper, corresponding to the rise and fall of the stream. Two description of gauges were used. One was designed chiefly by Mr. Stierle, of the U. S. Engrs. Office, Philadelphia. The minimum flows were found to be so small that the larger flows had to be determined. These had to be found by other methods, for the weirs would only carry, at the most, two feet in depth, while the water in the streams sometimes raised as high as sixteen feet. The measurements of the large flows were made mostly by the use of electric current meters. The measurements had to be made from bridges, and where none existed, in proper places, small suspension bridges were put up. One was built over the Perkiomen, at Frederick, of 120 feet span, and one over the Neshaminy, at Rush Valley, of 133 feet span. By means of the meter, the velocity of the water was taken at a great number of places in a line across the stream, and a close estimate of the velocity of the whole cross section determined. Stream gauges were placed near the meter stations, to be read when measurements were made, answering the same purpose as those connected with the weirs.

In some cases, large flows were measured by getting the velocity of the stream, by means of pole floats. When used, care was taken to have the length of them as near the depth of the water as possible, and they were run at as many stations across the stream, as was necessitated by the changes in the even flow of the stream. The rise and fall of the water during freshets was so sudden, and the stations, eleven in number, were so scattered—the water-sheds covering five hundred square miles—that it was impossible to get to, and make measurements of, more than one or two streams during a freshet. Then, many times, the freshets would come in the night, and nothing could be done but the taking of continuous readings of the stream gauges.

To overcome these difficulties with our small force, and get at least fair measurements of all the streams at the high point of a freshet, "maximum stream gauges" were set up on most of the streams. A place was chosen where the bed of the stream was uniform in width and slope, and two similar gauges set up. They were usually from two hundred to five hundred feet apart. They were made in the form of a box from eight to twelve feet long and six inches square inside. One side opened as a door. They were placed on end and shielded and supported by heavy timbers, imbedded in the soil or bolted to the rock bottom. Vertically through the centre of the box ran a brass rod, which was graduated. A metallic float ran on the rod in such a manner that it would rise with the water, but would remain fixed on the rod, at the highest point the water reached, after it had fallen. The two gauges were connected by levels, and from the gauge readings the slope of the water was determined. From this the velocity of the stream was found by the Kutter formula. The daily flows of all the streams have been tabulated, from the commencement of the gauging in July, 1883, to January 1st, 1886, and the field is still being continued. The daily flows have also been shown graphically on sheets, with the rainfall on the water-shed and the temperature annexed. The connection between the three is well shown. Rain-gauge stations were established over all the water-sheds, and the data obtained from them,

combined with that from previously existing gauges, which was kindly furnished us by the observers, have also been plotted graphically, showing plainly the variations of the rainfall over large areas. Three automatic rain-gauges were used to show the intensity of the storms.

THE CORNWALL IRON MINES, LEBANON CO., Pa.

Regular Meeting, April 17th, 1886.—Mr. E. V. d'Invilliers spoke upon the geological position, characteristic features and method of mining the ore at these mines illustrating his remarks with several maps and cross-sections, and a relief model of the mines and contiguous territory, constructed by Mr. A. E. Lehman.

The ore deposit occurs in three hills, five miles south of Lebanon, whose summits are 870, 715 and 700 feet a. t. (above tide), Lebanon being 471 ft. a. t., and Cornwall, at the base of the Middle Hill, 575 ft. a. t.

The extreme length of this magnetic ore deposit is 4400 ft. in a general east and west line; its breadth in Big Hill 400′; in Middle Hill 800′, and in Grassy Hill 600′; and its area is about 63 acres.

The ore is surrounded on three sides by a steeply sloping wall of dolerite (trap) rock 100′ ± thick, the Mesozoic sandstone abutting against the south-west dipping ore on the south side of the deposit.

The ore was referred to the lime-shale transition layers between the Siluro-Cambrian limestone and the Hudson River slates; is magnetic, practically free from phosphorous, but contains considerable sulphur and some copper, and, except in the soft surface ore, all requires roasting before it is worked in the furnace.

There are three commercial grades of ore; but the bulk of the output is the No. 3 "select ore," mostly lump, with about 48 per cent. of iron and 2.5 to 3 per cent. sulphur

Mining at present is carried on entirely above water level, though the records of several bore holes have established the great depth of this deposit beneath the water plane; bore hole No. 4, in the east end of Middle Hill, being down 325′ below the surface, or to 282′ a. t., without any trap or other foot wall being struck.

The ore is mined in successive terraces and stopes, as in huge open quarries, and by means of six compressed air drills, large quantities can be mined upon short notice. The output for the year 1885 reached 508,864 tons, 5 cwt., and the total to January 1st, 1886, in round numbers, 7 *million tons.* Probably 30 million tons still remain *above* water level, before there will be any necessity to tap the underground deposit.

Mr. d'Invilliers' paper upon the subject was read at the Pittsburgh Meeting (February, 1886) of the American Institute of Mining Engineers, and will appear in Vol. XIV of their Transactions. His remarks were preliminary to a description of the model, by Mr. Lehman.

THE MODEL OF THE ABOVE MINES.

Mr. A. E. Lehman then exhibited, and described the method of construction of, the Model of the above mine. It is built entirely of layers of cardboard, the perpendicular edges of which are brought to slope by engraving tools. It was so constructed that the accurate location of the contour lines was preserved, and they were drawn in ink on the finished surface, adding greatly to its practical value and intelligibility. Property lines, railroads and other topographical features and areas are shown in ink and color. The whole work is one of remarkable neatness.

NOTES UPON HON. JOHN BIGELOW'S REPORT ON THE PANAMA CANAL.

Regular Meeting, May 15th, 1886.—Mr. E. S. Hutchinson read a paper giving a Résumé of the Report of the Hon. John Bigelow on the Panama Canal, made to the New York Chamber of Commerce, April 15, 1886.

After stating that the Chambers of Commerce of some European cities, as well as that of New York, were invited by M. De Lesseps to send delegates to assist at the Inspection of the Canal in February last, he briefly describes the work as follows:

The project contemplates the construction of an open ship-canal, without locks, from Colon, on the Atlantic side of the Isthmus, up the Valley of the Rio Chagres, through the Cordilleras at Culebra, and down the Valley of the Rio Grande to the bay near Panama, on the Pacific. Beginning at sea level at Colon the canal reaches Matachin, 27 miles, with cuttings varying from 20 feet to 168 feet; from Matachin to Culebra, 7 miles, the hills are from 100 to 240 feet, while at the latter point, the crossing of the Cordilleras, the maximum cut is 320 feet; along the 8 miles to sea level the decline is rapid; the 4 miles remaining will be dredged 325 feet wide in Panama Bay to Perico Island. The plan necessarily includes the erection of a breakwater and other extensive harbor improvements at Colon; with a breakwater and jetties, and a tidal-basin at La Boca. Depth of water to be maintained 27 to 29 feet. In the lowlands the widths will be 164 and 72 feet, top and bottom respectively; and in the Cordilleras they will be 102 and 78 feet.

The original plan, Mr. Hutchinson believes, contemplated the construction of sidings or passing places every 6 miles, but the Report mentions only one, 3 miles long, at Tavernilla, 19 miles from Colon.

The most serious obstacles to be overcome are treated of under four heads:

First.—The control of the River Chagres.

Second.—The cut through the Cordilleras at Culebra.

Third.—Keeping the channel open from mouth of the canal at La Boca to near Perico Island.

Fourth.—Securing the labor required at practicable rates.

The Report states that the Chagres, which with its tributaries has a normal flow of 450 to 500 cubic feet per second, has recently been known to rise 40 to 50 feet and discharge 2,550 cubic yards per second, and in 1857, Col. Totten gauged it at 2,093 cubic yards per second; and that the improved channel of the Chagres will carry off 520 cubic yards per second, so that at a time of maximum flow 1,573 cubic yards per second will have to be provided for.

He mentioned the two plans that have been proposed to get rid of this dangerous surplus: one, the construction of lateral channels, and the other, the building of a catch-water basin large enough to hold a flood or two of the Chagres, and added that within a few days he had been officially advised that both plans were still under consideration by the Technical Commission, though Mr. Bigelow is of the opinion that the "Dam" project is most in favor.

He condensed from the Report a description of the "Dam": three-quarters of a mile long, 140 feet high, 1,300 feet wide at base, with exterior slope of 4 to 1. Waste weir a 20 feet diameter tunnel, with in-dam orifice 80 to 100 feet *above* bottom of dam. Quantity of material 9 millions cubic yards, with a reservoir capacity of 4 billions cubic yards. He pointed out the important omission from the Report of the

results of the examinations for depth of foundation for the dam, and also of the estimate of the cost of construction.

He quoted from the Report that the maximum cut at Culebra was 320 feet, and that quantity of material to be removed at this point, and within 1½ miles, was 26 millions cubic yards. The Report goes on to state that the Anglo-Dutch Company which has contracted to remove 915,000 cubic yards per month, has never reached 131,000 cubic yards per month, that only 1¼ millions cubic yards had been removed up to January 1st, 1886, and that this contract was so modified that from 800,000 to 432,000 cubic yards per month were to be taken out during the next three years, ensuring the completion of the work by July 1st, 1889.

Mr. Hutchinson concluded that from the meagre figures given this would be impossible, and that if there was no increase in the rate fifteen years would be required, even if no serious nor unforseen delays occur. He noted the important fact that the company was to furnish machines and men, and that having failed in their part of the contract, the contractors were released from all obligations.

He was of opinion that the Report did not show that careful surveys had been made of the Panama terminus, as important questions mentioned elsewhere were not touched upon. "Plans," it states, "are in contemplation for a dam across the Rio Grande, for a dyke 4 miles long from Gama Point to Naos." No mention is made of the tidal-basin three-quarters of a mile square, which is deemed indispensable, and has recently been estimated will cost 30 millions dollars. It went on to state that very little work has been done at this terminus, none within the shore line, and that very extensive repair and construction shops had been erected near the Mangrove swamps, and that the pestilential exhalations were particularly fatal to skilled labor.

He noted that the Report treated the labor question quite fully; it pointed out that the native supply was very limited and uncertain, and that agents of the company were constantly employed in all of the available markets gathering recruits; that the percentage of desertions was heavy; that of the 12,000 men on the rolls, the number is thought to be considerably exaggerated; that unskilled labor, which at the beginning had been 90c., was now $1.75 per day; that skilled black labor ranged from $2.00 to $2.75 per day, while white mechanics received $5.00, gold.

He drew attention to that portion of the Report which states that the American Contracting and Dredging Company has a contract for excavating 39¼ millions cubic yards of dredgible material for the port of Colon, for the main canal, and from the auxiliary canals, for the improvement of the Rio Chagres; and extending from Colon to Matachin, about 27⅓ miles. There will be 18⅔ miles of auxiliary canal. Work was begun early in 1884 and has been kept up steadily, there being at present, seven dredges at work. Up to January 31st, of the present year, this company had excavated about 7,000,000 cubic yards, the amount for January being 952,000 cubic yards. Mr. Bigelow appears to have no doubt but this company will have its work completed by the stipulated time, December 1st, 1887.

Mr. Hutchinson also observes that a list is given of *six* contractors who were to have had contracts amounting to 125 million dollars, only one of which, the American Contracting and Dredging Company, is mentioned as having done any work, unless it may be that the Anglo-Dutch Company, which is reported as at work at the Culebra cut, is the same as the "Societé de Traiaux Publique et Construction Companie," and which he is unable to determine.

He considered it desirable to know whether or not these companies have thrown up their contracts? Whether they are still at work? Where on the line are they located? What amount of work has been done by each of them?

He quotes from the Report, that on January 31st there were 21 dredges and 82 excavators on the work, "with the auxiliary boats, trains and machinery," and adds that for further details we must seek elsewhere. He abstracted the quantities as follows:

The total excavations necessary to complete the work was given by the engineers at 157,000,000 cubic yards. To February 1st, 1886, there have been done 18½ millions—11¾ per cent., leaving 138½ millions yet to be done—88¼ per cent.

Total excavation, January 1, 1886	17,019,000	cubic yards.
" " September 1, 1884	10,225,000	"
" " 16 months	6,795,000	"
Average per month, for 16 months; say	425,000	"
The work for January, 1886, was	1,400,000	"

He remarked that at the latter rate, about eight years from February 1st of this year would be required to complete the work, were there no other problems than that of excavation to be considered, and that the magnitudes and methods are so overwhelmingly great that they cannot be subjected to the ordinary rules of arithmetical computation.

Mr. Hutchinson pointed out that as regards the matter of expenditures, Mr. Bigelow adds nothing to Mr. De Lesseps' Report of July, 1885; nor is the date of closing of the financial year given. Adopting the figures of this report we have total amount realized to that date 94¼ million dollars; expenditures 73½ millions; balance 20¾ million dollars. Of the total expended only 23 million dollars—31 per cent.—were for installing machinery, clearing line and excavation; the remainder were for expenses of organization, supplies and plant. Since that date the company has received 25 million dollars, but what the expenses have been approximately for the past year, more or less, Mr. Bigelow does not inform us.

The paper concluded by remarking that the map accompanying the Chamber of Commerce Report was on the small scale of about 46 miles to the foot, and that it appeared to be a copy of one made to show the condition of the work June 1st, 1884—two years ago.

The final conclusion seemed to be that in the interest of engineering it was to be greatly regretted that the inspection and report had not been made by a thoroughly equipped engineer.

THE FIRST PERMANENT TRAMWAY IN AMERICA.

Regular Meeting, May 15th, 1886.—Dr. Robert Patterson Robins, introduced by Mr. Thomas M. Cleemann, presented the following:

The following notes, chiefly from contemporaneous newspapers, were collected with a view to discover whether the road in Delaware County was entitled to be considered the first tramway ever constructed in America. Arranged in their proper order, they seemed worthy of preservation, and they are now presented almost without comment.

At a meeting of the Assembly in 1790, a project for a canal was brought forward by Thomas Leiper and John Wall, of Delaware County, supported by a petition from the stone-cutters and masons of Philadelphia. Mr. Leiper desired the privilege of cutting a canal from the flowing of tide in Crum Creek to McIlvain's mill-dam, or William Leiper's mill-dam, in order to cheapen the cost of transportation of his stone from his quarries to tide-water. The mechanics stated that Mr. Leiper's stone *was the best produced* in the neighborhood of the city, and that the building of the canal would be an advantage to the public. Against this privilege John and Isaac McIlvain remonstrated, and nothing was done in the matter.[1]

The reason for this remonstrance can be readily understood, when we examine the topography of the proposed canal. Mr. Leiper wished to enlarge into a canal the old mill-race which led from McIlvain's to Leiper's Mills, the latter standing "just below the 'Big Road,' passing through the town of Ridley (now Leiperville)." In justice to Mr. Leiper, however, it must be said that the McIlvains were not entirely dependent upon the race for their motive-power.[2]

Being forced to abandon this project, Mr. Leiper cast around for some other method of transportation, but it was not until the year 1809, that the scheme of constructing a tramway was matured. In a memorandum-book kept in his own hand, commencing in 1807, and ending in 1810, we meet with the first evidences that he was holding under consideration such a scheme only so late as May, 1809. "In May of that year, he made an estimate for a railway three-quarters of a mile long, from his quarries to the landing place on Crum Creek," (at the head of tide) "to be built of wood, opposite to which he has a short profile of the work. The estimate is not complete, and the idea, so far as the work is concerned, seems to be abandoned until January or February of the following year. He then estimates three quarters of a mile of the railroad minutely, and arrives at the conclusion that it will cost, including the survey, $1592, 47–100."[3] So far from abandoning the project of a railway, as the quotation above would seem to imply, Mr. Leiper instituted an experiment to satisfy himself that the idea was feasible. He employed a millwright from Scotland, named Somerville, to lay a temporary track in the yard of the old Bull's Head Tavern, Second street north of Poplar lane.[4] The experiment is thus described:[5]

"We have the pleasure to inform the lovers of domestic improvements that a satisfactory experiment, at which we were present, was lately made in this city, by Mr. Thomas Leiper, of the great utility of railways for the conveyance of heavy burdens—an improvement which a few years ago was introduced into England—as in many cases a cheap and valuable substitute for canals. In the above experiment a railway was laid of two parallel courses of oak scantling, about four feet apart, supported on blocks or sleepers about eight (8) feet from each other. On this railway, which had an ascent of one-and-a-half ($1\frac{1}{2}$) inches in a yard, or 2° 23′, a single horse, under the disadvantage of a path of loose earth to walk on, hauled up a four wheel carriage, loaded with the enormous weight of $95\frac{1}{2}$ hundred weight, or 10,696 pounds.

"We are informed that Mr. Leiper is about to lay a Rail Way at Crum Creek, in

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[1] Westcott's History of Philadelphia, Chapter CCCIX. Feb. 16, 1873.

[2] John Hill Martin's History of Chester, p. 239.

[3] Delaware County Republican, Feb. 24th, 1860.

[4] Pennsylvania Magazine of Hist. and Biog., Vol. iv, No. 4, pp. 421, 422.

[5] "The Aurora," Sept. 27th, 1809.

Delaware County, for the conveyance of stone, from his quarry to the landing; a distance of about one mile.

"Robert Patterson, Prof. Math. Univ. of Pa.[6]
"Callender Irvine, Supt. U. S. [Military Stores.][7]
"John Glenn, Agent for Thomas Leiper.

"Being called upon by Thomas Leiper, Esq., to view his newly-made truck-waggon fixed on the railway, of about twenty-one yards in length, for the purpose of making experiments, exhibited in the yard of the Bull Tavern, Northern Liberties.

"I took the exact acclivity of the said rail or draught way, and found it to rise at the rate of one inch and an half to the yard.

"Philadelphia, July 31st, 1809.

"Reading Howell, Engineer.

"Nor can we close this brief notice of an interesting work without paying a merited tribute of applause to the patriotic enterprize of the gentleman who has been the *first in America* to engage in it; and we hope he may derive as much advantage from it as such an example to the public fully entitles him to."

Entirely satisfied with the success of these experiments, Mr. Leiper took immediate steps to push forward the work thus inaugurated, as the following advertisements show:

"RAILWAY.[8]

"I wish to contract for the digging part of a RAIL WAY from my quarries on Crum Creek to my landing on Ridley, the distance and level has been accurately ascertained by Mr. Reading Howell: the distance is exactly three-fourths of a mile, and an accurate statement of the quantity of digging required, may be seen from the plot in my possession, calculated by Mr. Howell. I also wish to contract for the making and laying the rail part of the same, consisting of wood, a specimen of which, as furnished by Messrs. Large and Winpenny, may be seen by applying to them at their manufactory, adjoining the Bull's Head in Second Street, in the Northern Liberties. The scantling for the above will be furnished on the ground.—I wish to progress in this work immediately.

"For more particular information apply to

"GEORGE G. LEIPER,
"on the premises, or to
"THOMAS LEIPER,
"Tobacconist, No. 274 Market St."

"September 27th."

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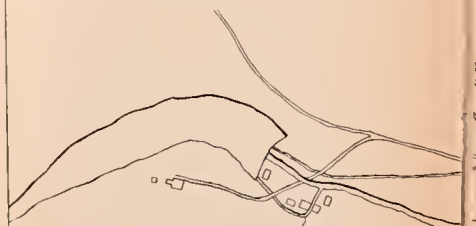
[6] Robert Patterson, son of Robert and Janet (Gibson) Patterson, b. Ireland, May 30th, 1743. Emigrated to America, 1768, and settled in Bucks County as Schoolmaster. Removed to Wilmington in 1774. Brigade-Major Revol. Army, 1776–1778. Prof. Math. Univ. of Pa., 1779. Vice-Provost id., 1810. Director U. S. Mint, 1805, Mem. Am. Philos. Soc., 1783, Secretary id., 1784, Vice-Pres. id., 1799, Pres. id. 1819. A.M. Univ. of Pa., 1788, LL.D. id., 1819. Married, May 9th, 1774, Amé Hunter, dau. of Maskell and Mary (Paget) Ewing. Died, July 22d, 1824.

[7] Callender Irvine, son of Gen. William J. and Mary (Callender) Irvine, b. 1774. Capt. Arts. and Engineers, June 1, 1798 to May 20th, 1801. Supt. Military Stores, 1804. Commissary General of Purchases, U. S. A., Aug. 8th, 1812. D. Philadelphia, Oct. 9th, 1841.

[8] "Aurora," Sept. 28th, 1809.

Draft

Exhibiting the view of the route of the Railway as contemplated by Thomas Leiper Esq.r from his stone saw Mill and Quarries on Crum Creek to his landing on Ridley Creek.



The rise from the Saw Mill to Mr. y distance 167.2 is at the rate of 5.783 to every perch = £ 34.5016 to each yard. From Mr. y 1.3 southwards of £ 14. being £ 7.4 £ it falls at the rate of 1.068 in every perch equal to a little more than a ft. of an inch to the yard, thence to near the landing 7.968 ft falls at the rate of 1.6875 to each perch equal 6 ft. 4 ½ inches to the yard.

October 18th 1809

Jas. Thomson

This above Draft is now annexed to illustrate a paper on the "First permanent Tram-way in America", read before the Engineers Club of Philadelphia May 15th 1885 by Robert Patterson Boyd M.D.

by Robert Patterson Field M.E. (Grandson of Thomas Leiper)

"LABORERS WANTED.[9]

Leiper's Snuff Mills, on Crum Creek, Oct. 28th, 1809.

I have contracted with Thomas Leiper, for the digging part of his RAIL WAY, from his stone quarries on Crum Creek, to his Landing on Ridley Creek. The work is now progressing, which I find to be a very easy process, for three yoke of oxen can plough from 10 to 15 inches deep, which I am to have the use of for the whole of the contract, from that circumstance nothing but shovels will be required for three-fourths of the way. Laborers who wish to engage will please apply to

"JOHN BRYCE
"on the premises."

"November 1."

The work of building and grading was immediately begun, the draft of the road being made by John Thomson,[10] and the railway was finished early in 1810. "The ascents were graded inclined planes, and the superstructure was made of white oak, with cross-ties and string-pieces. The cars or trucks were very similar to those now in use, the wheels being made of cast iron with flanges."[11] The road continued in active use until 1828, when it was superseded by a canal after the plan made by Mr. Leiper, but not carried into effect until three years after his death, when his son, the Hon. George Gray Leiper, concluded the work which had always been nearest to his father's heart." The site of the old road can still be seen, though it is in ruins, nothing remaining excepting the deep ruts made by the cross-ties. There has been a great deal of discussion of late years with regard to the claim of priority for this road, it having been claimed by various New England writers that an earlier tramway had been built in or near Boston. But as nearly as I can arrive at any conclusion upon the subject, the only road constructed before the building of Mr. Leiper's tramway in Delaware County was that on the western slope of Beacon Hill, which was designed and executed by Silas Whitney in 1807, and which was about a quarter of a mile in length. "It was used for the transporting of gravel from the top of the hill down to Charles Street, which was being filled up and graded. There were two trains of cars on the railway, so arranged that one train being loaded with gravel would in its descent pull up the empty train. While the full cars were being emptied, the unloaded cars were being filled, and in their descent would haul up the first train, thus doing the work without horses."[12] This road was, however, only temporary, and as the work of grading progressed, was gradually removed. It is, however, entitled to a mention as the first work of the kind in America, having been put into active operation at least two years before Mr. Leiper's preliminary and experimental railway in the yard of the Bull's Head tavern. Mr. Leiper's road in Delaware County was, however, the first permanent tramway constructed in this country; the next in point of date "was that laid in Nashua, N. H., in 1825; the third was the one laid down at Quincy Granite Quarries, in Massachusetts, in 1826–27; and the fourth,[13] the great enterprise at Mauch Chunk, Pennsylvania, nine miles in length, to which the former ones are mere child's play."[14]

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[9] "Aurora," Oct. 29th. 1809.

[10] The original map of the road is now in the possession of the "Delaware County Institute of Science," having been presented to the Institute by Dr. Joshua Ash, who procured it from the late J. Edgar Thomson, Esq. A reduced copy is presented with this paper.

[11] Smith's History of Delaware County, p. 389.

[12] American Historical Record, vol. i., p. 405.

[13] Built May, 1827. See Egle's History of Pennsylvania, i., 246.

[14] J. Hill Martin's History of Chester, page 242.

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Donkin and Salter—The Measurement of Water over Weirs.
Fadda—Railway Rolling Stock in Italy.
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Journal—August and October, 1885.

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The International Standard—September, 1885.

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From MR. WM. HAMILTON, Supt. Toronto Water works, Toronto, Canada.

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Report on Sewerage and Drainage of Orange, N. J. 1885.

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Spinning.
Pottery.
Acids, Alkalies and Oxides.
Writing Instruments and Materials.
Furniture and Upholstery.
Aeronautics.
Preparation and use of Tobacco.
Books, Portfolios, Card Cases, etc.
Sewing and Embroidering.
Umbrellas, Parasols, Walking Sticks, etc.
Toys, Games and Exercises.
Steam Engine.
Carriages, Vehicles, etc.
Needles and Pins.
Lamps, Chandeliers, etc.
Paints, Colours and Varnishes.
Music and Musical Instruments.
Sugar.
Preparing and Cutting Cork; Bottling Liquids; Securing and Opening Bottles, etc.
Medicine, Surgery and Dentistry.
Brushing and Sweeping.
Skins, Hides and Leather.
Artist's Instruments and Materials.
Ventilation.
Raising, Lowering and Weighing.
Farriery.
Locks, Latches, Bolts, etc.
Safes, Tills, etc.
Oils, Fats, Soap and Candles.
Water Closets, Earth Closets and Urinals, etc.
Hinges, Door Springs, etc.
Air, Gas, and other Motive Power Engines.
Nails, Rivets. Nuts, Bolts and Screws.
Railways.
Cooking, Bread Making, and Preparation of Confectionery.
Masts, Sails, Rigging, etc
Anchors.
Hydraulics.
Metallic Pipes and Tubes.
Drains and Sewers.
Mining, Quarrying, Tunnelling and Well-Sinking.
Wearing Apparel.
Milking, Churning and Cheese-Making.
Optical and Mathematical Instruments.
Casks and Barrels.
Preparation of India Rubber and Gutta Percha.
Steering and Manœuvring Vessels.
Agriculture.
Purifying and Filtering Water.
Harbors, Docks and Canals.
Artificial Leather, Oilcloth, Oilskin, etc.
Trunks, Portmanteaus, Boxes and Bags.
Grinding Grain and Dressing Flour and Meal.
Chains, Chain Cables, etc.
Ice Making Machines, Ice Safes and Ice Houses
Unfermented Beverages and Mineral Waters.
Washing and Wringing Machines.
Fire Engines, Extinguishers, Escapes, Alarms, etc.
Tea, Coffee, Chicory, Chocolate and Cocoa.
Dressing and Finishing Woven Fabrics, and Manufacturing Felted Fabrics.
Letterpress and Similar Printing.
Lace-Making, Knitting, Netting, Braiding and Plaiting.
Cutting, Folding and Ornamenting Paper.
Carriages and other Vehicles for Common Roads.
Manufacture of Iron and Steel.
Brewing, Wine-Making and Distilling Alcoholic Liquors.
Fire Arms, Ammunition, etc.
Starch, Gum, Size, Glue, etc.

ADDITION TO EXCHANGE LIST.

Sibley College, Cornell University, Ithaca, N. Y.

BOOK NOTICES.

THE CIVIL ENGINEER'S POCKET-BOOK. By John C. Trautwine, C. E. Twenty-fifth thousand, revised by John C. Trautwine, Jr., C. E. New York: John Wiley & Sons, 1886.

The last edition (the twenty-second thousand) of this work was noticed in our Vol. V, No. 1, of May, 1885. The editor now takes advantage of the call for a new edition, by making the following changes. We quote his preface:

"For this edition, the articles on Flow of Water in Channels, pp. 268, etc., Friction, pp. 370, etc., and Timber Preservation, pp. 425, etc., have been re-written. In the first named, Kutter's formula is given, with tables to facilitate its use, and instructions for preparing a diagram from which its results may be taken by inspection. Under Friction are given the results of recent researches, including the now famous experiments of Captain Douglas Galton on brake friction. The new article on Timber Preservation embodies, besides other matter, results recently published by a Committee of the American Society of Civil Engineers."

"Prices and descriptions of manufactured articles, etc., have been revised to date."

"A number of changes have been made in the articles on Force in Rigid Bodies, and Trusses, in order to further simplify the treatment of those subjects. These changes include the enlargement, and the re-arrangement in more convenient form, of the articles on Gravity and Falling Bodies, Descent on Inclined Planes, Angular Velocity, Moment of Inertia, Radius of Gyration, and Centrifugal Force."

"On p. 230, *a*, the subject of Distribution of Pressure in Plane Surfaces, is explained more fully than in earlier editions. The empirical formula, p. 243, for flow of water in pipes, has been so modified as to give more closely approximate results. An article on the Fatigue of Materials has been added, p. 435. The rules for Strengths of Pillars, pp. 439, etc., and those for Limited Deflections of Beams, pp. 510, etc., have been simplified. On p. 678, is given a summary of the results of Mr. Eliot C. Clarke's recent ex-

periments on the Strength, etc., of Cements. Many other minor improvements have been made."

"Advantage has been taken of these changes to still further extend the substitution of the larger for the smaller type."

THE FIELD PRACTICE OF LAYING OUT CIRCULAR CURVES FOR RAILROADS. By John C. Trautwine, C. E., Twelfth Edition, revised by John C. Trautwine, Jr., C. E. New York: John Wiley & Sons, 1886.

The eleventh edition of Trautwine's "Curves," received in 1882, was practically a new work. It contained nearly twice as much matter as its predecessor. The contents of the earlier editions had been re-written and put into such a shape as to be more easily intelligible and more convenient for use. The new matter consisted chiefly of a large number of field problems, a description (with vertical cross section) of the engineer's transit, and directions for its adjustment, and a table of versed sines. For each problem the necessary changes of the signs + and — are given for cases where the total angle subtended by the curve exceeds 90°.

The edition before us is practically identical in subject matter with the one just referred to; but its appearance has been greatly improved in all respects. All of the former cuts have been replaced by new and much finer ones; and better paper, ink and presswork combine to make it a handsome book. It is bound in a new and attractive style.

THE CIVIL ENGINEER'S FIELD BOOK, designed for the use of the Locating Engineer. By Edward Butts, Civil Engineer. New York: John Wiley & Sons, 1886. Price $3.00.

Most of this book, the latest attempt to fill what to us seems an imaginary want, is taken up with a table giving tangent distances and lengths of curves for each even degree of curve from 1 to 10, and for every angle of intersection varying by single minutes up to 90°. In other words, it is a solution of the two equations

$$t = R \tan \tfrac{1}{2} I$$

and

$$L = \frac{I\ R}{57.3}$$

where t is the tangent distance, R is the radius of the curve, I is the intersection angle, in degrees, and L is the length of the curve.

If anyone thinks that he will require to solve these two equations, in locating a railroad, sufficiently often to warrant his using this book of tables, we advise him to get it. In our own experience we have not so found it necessary very often to calculate tangent distances on the ground. We start a curve where the paper location says it should start, and if the tangent point does not come at the proper height, we run in a new curve by changing either the point of curve or the radius, whichever seems to fit the ground best, using the well-known problems numbered 12 and 13 in the book. If, too, a man relied on these tables only, he might feel very much embarrassed if his curve was not of an even degree; a not uncommon thing, but which the tables do not assume.

A most convenient table of tangent distances, which many engineers make for themselves on a single sheet of paper, the size of the pages of whatever book of natural sines, etc., they use, is one giving the tangent distances for angles of intersection, varying by even minutes, calculated for a radius of 1. Multiplying by the actual radius gives the distance for any curve.

The problems in this book are worked out apparently with the object of being perfectly clear to a person unacquainted with the use of formulas. Leaving out of the consideration that a man who had any difficulty in using a formula intelligently, would scarcely be competent to undertake the location of a railroad, yet it seems to us that one who did not understand the problem before, would find it difficult sometimes to understand how to apply it from the examples in the book; and if it meets a ready sale, one can imagine that many a purchaser will be puzzled at finding in several of the problems a reference to *Ec*, when there are no such letters in the figure. It is presumed that these letters are intended as an abbreviation of *et cetera*.

The old problems of reversed curves are included, though such curves have been obsolete on first-class roads for many, many years. C———.

ENGINEERS' CLUB OF PHILADELPHIA

ORGANIZED DECEMBER 17th, 1877.

LIST OF MEMBERS.

FEBRUARY, 1886.

HOUSE,

1122 GIRARD STREET,

PHILADELPHIA, PA.

PAST OFFICERS.

1878.

President, Prof. L. M. Haupt. *Vice-President*, Coleman Sellers, Jr.
Secretary and Treasurer, C. E. Billin.

1879.

President, Thos. C. Clarke. *Vice-President*, J. B. Knight.
Recording Secretary, Herman Hoopes.
Corresponding Secretary and Treasurer, C. E. Billin.

Directors: Rudolph Hering, W. G. Neilson, Percival Roberts, Jr., Coleman Sellers, Jr., and D. Mc. N. Stauffer.

1880.

President, Frederic Graff. *Vice-President*, Percival Roberts, Jr.
Recording Secretary, Wilfred Lewis. *Corresponding Secretary*, Howard Murphy.
Treasurer, A. R. Roberts.

Directors: Geo. Burnham, Jr., Rudolph Hering, Herman Hoopes, Coleman Sellers, Jr., and John A. Wilson.

1881.

President, Strickland Kneass. *Vice-President*, Henry G. Morris.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.

Directors: Geo. Burnham, Jr., T. M. Cleemann, Jos. J. de Kinder, Frederic Graff and Rudolph Hering.

1882.

President, Rudolph Hering. *Vice-President*, Percival Roberts, Jr.,
Recording and Corresponding Secretary and Treasurer, Howard Murphy.

Directors: T. M. Cleemann, Jos. J. de Kinder, Frederic Graff, Strickland Kneass and Wilfred Lewis.

1883.

President, Henry G. Morris. *Vice-President*, Wm. A. Ingham.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.

Directors: Frederic Graff, Strickland Kneass, T. M. Cleemann, Rudolph Hering and Percival Roberts, Jr.

1884.

President, Col. William Ludlow. *Vice-President*, Jos. J. de Kinder.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.

Directors: Frederic Graff, Washington Jones, T. M. Cleemann, Rudolph Hering and H. G. Morris.

1885.

President, Jos. J. de Kinder. *Vice-President*, Jos. N. Du Barry.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.

Directors: T. M. Cleemann, Frederic Graff, Rudolph Hering, Col. Wm. Ludlow and H. G. Morris.

PRESENT OFFICERS.

1886.

President, Washington Jones. *Vice-President*, T. M. Cleemann.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.

Directors: Frederic Graff, Rudolph Hering, Wm. A. Ingham, Col. Wm. Ludlow and H. G. Morris.

LIST OF MEMBERS

—WITH—

ADDRESS AND DATE OF ELECTION.

Members are particularly requested to keep the Secretary constantly informed as to their correct address.

HONORARY MEMBERS.

Haupt, Gen. Herman, April 6th, 1878.
Civil Engineer,
Mountain Lake, Giles Co., Va.

Robinson, Moncure, April 6th, 1878.
Civil Engineer,
1319 Spruce St., Phila.

Walter, Thomas U., Feb. 5th, 1881.
Achitect,
720 N. Broad St., Phila.

CORRESPONDING MEMBERS.

Buckman, G. R., May 17th, 1879.
Colorado Springs,
Colorado.

Fletcher, Robert, April 6th, 1878.
Professor of Civil Engineering,
Darmouth College, Hanover, N. H.

Pontzen, E., Oct. 4th, 1879.
Civil Engineer,
4 Rue de Castellane, Paris, France.

Robinson, J. F., April 6th, 1878.
Supt. Atlas Works,
Manchester, England.

Schenck, A. A., Feb. 16th, 1878.
Civil Engineer,
4006 Baltimore Ave., Phila.

ACTIVE MEMBERS.

Abercrombie, F. P., June 16th, 1883.
Asst. Engineer P. R. R.,
Sunbury, Pa.

Africa, J. Simpson, June 18th, 1881.
Secretary of Internal Affairs,
Harrisburg, Pa.

Allen, Kenneth, March 15th, 1884.
Civil Engineer,
Northboro, Mass.

Ashburner, Chas. A., Dec. 17th, 1877.
Geologist in Charge Survey of the Anthracite Coal Fields,
907 Walnut St., Phila.

Auchincloss, W. S., March 5th, 1881.
Civil Engineer,
209 Church St., Phila.

Bache, R. Meade, Nov. 1st, 1884.
Asst. U. S. C. & G. Survey,
4400 Sansom St., Phila.

Baermann, P. H., March 5th, 1881.
Civil Engineer,
P. O. Box 228, West Troy, N. Y.

Baizley, Rudolph R., June 20th, 1885.
Mechanical Engr.,
520 S. Delaware Ave., Phila.

Baldwin, Wm. Henry, Feb. 5th, 1881.
Civil Engineer,
Yonkers, N. Y.

Barber, Dana C., Oct. 4th, 1884.
Civil & Sanitary Engineer, Phila. Water Dept.,
P. O. Box 505, Phila.

Barnard, Louis H., April 7th, 1883.
Prof. Civil Engineering State College,
State College, Centre Co., Pa.

Barnes, Edward H., March 15th, 1884.
Civil Engineer,
Bedford, Bedford Co., Pa.

Barnes, Oliver W., June 16th, 1883.
Chief Engr. South Penna. R. R.,
57 Broadway, N. Y.

Bassett, Phillips, Feb. 20th, 1886.
Civil and Sanitary Engineer,
784 Broad St., Newark, N. J.

Beardsley, Arthur, Jan. 18th, 1879.
Professor of Civil and Mechanical Engineering,
Swarthmore College, Swarthmore, Delaware Co., Pa.

Biddle, Wm. F., Nov. 1st, 1884.
Civil and Mining Engineer,
209 S. 3d St., Phila.

Billin, Chas. E., Dec. 17th, 1877.
Selling Agent for Rolling Mills & Forges,
Room 63, 115 Dearborn St., Chicago, Ill.

Birkinbine, Harry, May 1st, 1880.
Chief Engineer City Water Works Co.,
Council Bluffs, Iowa.

Birkinbine, John, Oct. 4th, 1884.
Civil and Mechanical Engineer,
152 S. 4th St., Phila.

Bixby, Wm. H., June 16th, 1883.
Capt. of Engineers, U. S. A.,
U. S. Engineers' Office, Wilmington, N. C.

Bland, Geo. P., March 5th, 1881.
Civil Engineer,
3214 Woodland Ave., Phila.

Bonzano, Maximilian F., March 1st, 1879.
Division Engineer P. & R. R. R.,
9th and Green Sts., Phila.

Borda, Eugene, Oct. 2d, 1880.
Metallurgist and Mining Engineer,
326 Walnut St., Phila.

Borden, Philip D., Jr., Feb. 20th, 1886.
City Engineer,
Fall River, Mass.

Bowen, F. H., Jr., Oct. 4th, 1884.
Asst. Engr. P. & R. R. R.,
Mount Pleasant House, Mt. Airy, Phila.

Boyd, John T., May 1st, 1880.
Mechanical Engineer, I. P. Morris Co.,
423 S. 15th St., Phila.

Bramwell, Geo. W., April 19th, 1884.
Div. Engr. S. V. R. R.,
Roanoke, Va.

Brendlinger, P. F., Jan. 10th, 1880.
Chief Engr. R. & P. and P. & M. R. Rs.,
Pottsville, Pa.

Brewer, Paul C., April 19th, 1884.
Asst. Engr. P. R. R.,
1333 N. 12th St., Phila.

Briand de Morianville, V. E., March 15th, 1884.
Civil Engineer and Architect,
215 E. Chelten Ave., Germantown, Phila.

Bridgers, R. R., Jr., Nov. 7th, 1885.
Supervisor P. R. R.,
Trenton, N. J.

Brooke, Walter C., May 17th, 1884.
Engr. Mineral R. R. & Mining Co.,
Shamokin, Northumberland Co., Pa.

Broomell, A. P., Dec. 5th, 1885.
Mech. Engr., Supt. Engine Dept., Penna. Agricultural Works,
York, Pa.

Brosius, Milton L., Nov. 19th, 1881.
Mechanical Engineer,
Lewistown, Pa.

Brown, T. Benton, June 21st, 1884.
Brown & Goodnow, Engineers,
Bethlehem, Pa.

Bruner, Daniel P., Dec. 1st, 1883.
Civil Engineer,
Germantown, Phila.

Buchholz, Chas. W., May 1st, 1880.
Civil Engineer,
3823 Powelton Ave., Phila.

Burnham, Geo., Jr., Dec. 17th, 1877.
Baldwin Locomotive Works,
500 N. Broad St., Phila.

Burnham, William, Dec. 17th, 1877.
Secretary and Treasurer Standard Steel Works,
220 S. 4th St., Phila.

Burr, Wm. H., May 2d, 1885.
Phœnix Bridge Co.,
Phœnixville, Pa.

Cabot, W. Brooks, May 17th, 1884.
Engr. Everett Iron Co.,
Everett, Bedford Co., Pa.

Campbell, John W., Nov. 7th, 1885.
Asst. Supervisor P. R. R.,
Blairsville, Pa.

Cassatt, A. J., Nov. 19th, 1881.
Civil Engineer,
233 S. 4th St., Phila.

Cassin, Isaac S., June 18th, 1881.
Mechanical and Civil Engineer,
1404 N. 12th St., Phila.

Chamberlain, Edwin, June 21st, 1884.
Div. Engineer P. & R. R. R.,
1132 N. 6th St., Reading, Pa.

Chance, Dr. H. Martyn, Dec. 6th, 1879.
Mining Engineer,
Emaus, Lehigh Co., Pa.

Chaplin, W. S., Jan. 14th, 1882.
Prof. Engineering, Harvard University,
16 Prescott St., Cambridge, Mass.

Chauvenet, S. H., Jan. 18th, 1879.
Mgr. Robesonia Iron Co., Limited,
Robesonia, Berks Co., Pa.

Cheyney, Geo. S., Jr., June 20th, 1885.
Asst. Engr. Phila. Water Dept.,
Cheyney, Delaware Co., Pa.

Christie, James, March 15th, 1884.
Mech. Engr. Pencoyd Iron Works,
Pencoyd, Pa.

Church, J. B., July 1st, 1882.
Mining Engineer,
Geneva, N. Y.

Church, W. S., July 1st, 1882.
Asst. Engineer New Aqueduct,
215 Stewart Building, N. Y. City.

Churchill, Chas. S., Nov. 7th, 1885.
Prin. Asst. Engr. P. & M. R. R.,
Pottsville, Pa.

Claghorn, C. R., Oct. 4th, 1884.
Asst. 2d Geol. Surv. of Pa.,
Bernice, Sullivan Co., Pa.

Clarke, H. W., April 7th, 1883.
Engineer in Charge N. Y. & Pa. State Boundary Survey,
11 Granger Block, Syracuse, N. Y.

Clarke, Thos. C., Feb. 2d, 1878.
Union Bridge Co.,
Well's Building, 18 Broadway, Room 713, New York City.

Cleemann, Thos. M., (*Vice President*), April 20th, 1878.
Civil Engineer,
2135 Spruce St., Phila.

Clement, F. H., Jan. 14th, 1882.
Div. Engineer S. Penna. R. R.,
Everett, Bedford Co., Pa.

Cloud, John W., June 21st, 1884.
Engr. of Tests, P. R. R.,
P. O. Box 655, Altoona, Pa.

Codman, John E., Jan. 18th, 1879.
Asst. Engineer Phila. Water Department,
2145 Bainbridge St., Phila.

Coe, W. W., May 6th, 1882.
Chief Engineer N. & W. R. R. and S. V. R. R.,
Roanoke, Roanoke Co., Va.

Cofrode, Jos. H., March 5th, 1881.
Bridge Builder,
257 S. 4th St., Phila.

Collins, T. Earl, Jan. 8th, 1881.
Mechanical Engineer,
1225 Spruce St., Phila.

Colton, O. B., Dec. 17th, 1877.
Civil Engineer with Wilson Bros. & Co.,
2009 Wallace St., Phila.

Constable, Howard, Feb. 16th, 1878.
Hydraulic Engr.; Western Rep. H. R. Worthington Hydraulic Works,
No. 3 W. 30th St., N. Y.

Constable, Stevenson, April 2d, 1881.
Civil and Mechanical Engineer,
707 Walnut St., Phila.

Converse, John H., May 17th, 1884.
Baldwin Locomotive Works,
500 N. Broad St., Phila.

Cooper, Wm. A., March 2d, 1878.
Mechanical Engineer with Alan Wood & Co.,
Conshohocken, Pa.

Cooper, Wm. B., June 18th, 1881.
Civil Engineer,
Fort Edward, N. Y.

Corlies, Franklin H., Oct. 2d, 1880.
Mechanical Engineer with Wm. Sellers & Co.,
1616 Vine St., Phila.

Cornelius, H. R., Jan. 9th, 1886.
Mech. Engr., Southwark Foundry and Machine Co.,
430 Washington Ave., Phila.

Corthell, E. L., June 20th, 1885.
Chief Engr. Tehuantepec Ship Ry.,
Room 709, 34 Nassau St., N. Y.

Covode, J. H., Nov. 7th, 1885.
Asst. Supervisor P. R. R.,
28th St., Pittsburgh, Pa.

Cox, Allan, Nov. 7th, 1885.
Civil Engr., K. C. R. R.,
Covington, Ky.

Coxe, Eckley B., June 21st, 1884.
Mining Engineer,
Drifton, Luzerne Co., Pa.

Coxe, W. E. C., Nov. 1st, 1884.
Pres. Montour Iron & Steel Co.,
Reading, Pa.

Craighill, Wm. P., Nov. 7th, 1885.
Lieut. Col. of Engineers, U. S. A.,
378 St. Paul St., Baltimore, Md.

Cramp, Chas. H., Jan. 18th, 1879.
Ship Builder,
1736 Spring Garden St., Phila.

Cramp, Edwin S., March 5th, 1881.
Marine Engineer,
1515 Oxford St., Phila.

Cranmer, W. Clarence, Jan. 18th, 1879.
Surveyor and Regulator, 3d Phila. Survey District,
719 Sansom St., Phila.

Cresson, Geo. V., Jan. 12th, 1884.
Machinist and Manufacturer,
S. E. Cor. 18th and Hamilton Sts., Phila.

Creswell, Samuel J., Jan. 24th, 1885.
Iron Founder,
23d and Cherry Sts., Phila.

Crizuka, Mataro, June 21st, 1884.
Mech. Engr., Baldwin Locomotive Works,
500 N. Broad St., Phila.

Crowell, J. Foster, June 16th, 1883.
Engineer of Construction P. R. R.,
131 Maplewood Ave., Germantown, Phila.

Cruse, Arthur R., Jan. 13th, 1883.
Mechanical Engineer,
39 Laurel St., Phila.

Darrach, Chas. G., April 20th, 1878.
Civil Engineer,
Ridley Park, Pa.

Datesman, George G. E., Nov. 7th, 1885.
Asst. Engr. Phila. Survey Dept.,
City Hall, Phila.

Davenport, R. W., May 17th, 1884.
Supt. Midvale Steel Co.,
Nicetown, Phila.

Dawson, Edwin F., May 21st, 1881.
Civil Engineer,
513 Linden St., Camden, N. J.

Dechant, William H., June 21st, 1884.
Div. Engineer P. & R. R. R.,
Mahanoy Plane, Schuylkill Co., Pa.

DeHaven, I. Norris, May 17th, 1884.
Foreman Wm. Sellers & Co.,
527 S. 42d St., Phila.

de Kinder, Joseph J., Dec. 6th, 1879.
Civil and Mechanical Engineer,
901 Walnut St., Phila.

Derbyshire, Wm. H., May 6th, 1882.
Mech. Engineer with Machine Tool Works,
24th and Wood Sts., Phila.

Dietz, Augustus, March 15th, 1884.
Mech. Engr., Hoff & Fontaine,
1162 N. 3d St., Phila.

Dilks, Albert W., Dec. 1st, 1883.
Architect,
1001 Chestnut St., Phila.

d'Invilliers, Camille S., May 1st, 1880.
Assistant Engineer Penna. R. R. Co.,
Philipsburg, Centre Co., Pa.

d'Invilliers, Edward V., Jan. 10th, 1880.
Assistant 2d Geological Survey of Penna.,
711 Walnut St., Phila.

Drinker, Henry S., Dec. 6th, 1884.
Mining Engineer,
218 S. 4th St., Phila.

Du Barry, Jos. N., June 18th, 1881.
Third Vice President Penna. R. R.,
233 S. 4th St., Phila.

Dunbar, Wm. O., March 7th, 1885.
Mech. Engr., Signal Dept. P. R. R.
233 S. 4th St., Phila.

Dunne, H. W., Jan. 24th, 1885.
Supt. N. Y., Phila. & Norfolk R. R.,
Cape Charles, Va.

Durham, C. W., June 16th, 1883.
Pres. Durham House Drainage Co.,
158 W. 27th St., New York.

Dye, John H., March 6th, 1880.
Registrar Phila. Survey Department,
City Hall, Phila.

Edwards, J. W., Oct. 4th, 1879.
Mining Engineer,
Delaware Ave. and Green St., Phila.

Ehlers, Peter, March 5th, 1881.
Mechanical Engineer,
170 Broadway, Albany, N. Y.

Elliott, J. S., Dec. 6th, 1884.
Instructor in Civ. Eng., Univ. of Pa.,
34th and Locust Sts., Phila.

Elmer, H. N., Dec. 1st, 1883.
Civil Engineer and Building Inspector,
P. O. Box 276, St. Paul, Minn.

Estabrook, J. D., Dec. 2d, 1882.
Civil Engineer,
Coulter St., Germantown, Phila.

Evans, Geo. M., Jan. 12th, 1884.
Engineer and Contractor,
Roanoke, Roanoke Co., Va.

Evans, L. P., May 21st, 1881.
Engineer Phila. Bridge Works,
Pottstown, Pa.

Evans, Richard, Dec. 6th, 1884.
Asst. Engr. Dept. of Surveys,
City Hall, Phila.

Fairfax, Henry, March 5th, 1881.
Engineer and Contractor,
Roanoke, Roanoke Co., Va.

Feister, Henry P., June 16th, 1883.
Civil and Mechanical Engineer,
Room 9, 420 Library St., Phila.

Feldmann, Max B., Dec. 6th, 1884.
Mech. Engr., Penna. Globe Gas Light Co.,
635 Franklin St., Phila.

Felton, Herbert C., June 20th, 1885.
Sec., Treas. and Supt. Kaighn's Pt. and Phila. Ferry Co.,
Camden, N. J.

Ferrell, Joseph L., Oct. 2d, 1880.
Manager Southwark Foundry and Machine Works,
430 Washington Ave., Phila.

Field, Burr K., March 15th, 1884.
Asst. Engr. Berlin Iron Bridge Co.,
East Berlin, Conn.

Field, Robert P., April 7th, 1883.
Mining Engineer,
148 S. 4th St., Phila.

Flickwir, D. W., May 6th, 1882.
Supt. Shenandoah Valley R. R.,
Roanoke, Roanoke Co., Va.

Fontaine, John B., Jan. 24th, 1885.
Mech. Engr., Eagle Iron Works,
1646 Franklin St., Phila.

Ford, P. D., March 7th, 1885.
Supervisor Div. C, N. Y. Div. P. R. R.,
Tacony, Phila.

Forder, Emil, Nov. 1st, 1884.
Civil Engineer,
Revere House, Denver, Col.

Forsythe, W. T., June 20th, 1885.
Asst. Engr. Phila. Water Dept.,
Box 838, Phila. P. O.

Francis, Harry C., March 1st, 1879.
Manager Kensington Engine Works,
Beach and Vienna Sts., Phila.

Frost, Geo. H., June 16th, 1883.
Editor "Engineering News,"
13 Tribune Building, N. Y. City.

Fuller, Allen J., July 1st, 1882.
Mechanical Engineer Phila. Water Dept.,
749 N. 40th St., Phila.

Gardiner, John, June 18th, 1881.
Surveyor and Civil Engineer,
P. O. Box 255, Tucson, Arizona.

Garrett, Jesse, April 19th, 1884.
Water & Gas Works Appliances,
Care of R. D. Wood & Co., 400 Chestnut St., Phila.

Garrison, F. Lynwood, June 20th, 1885.
Mining and Metallurgical Engr.,
Radnor, Delaware Co., Pa.

Geer, Harvey M., June 18th, 1881.
Civil Engineer,
Ballston, N. Y.

Gerhard, Wm. Paul, March 15th, 1884.
Civil Engineer,
6 Astor Place, N. Y. City.

Gest, Alex. P., March 1st, 1879.
Asst. Engineer Pittsburgh Div. P. R. R.,
Union Station, Pittsburgh, Pa.

Gill, John L., May 2d, 1885.
Mechanical Engineer,
No. 2 Woodland Terrace, West Phila.

Gordon, Fred. W., Dec. 5th, 1885.
Mech. Engr., Gordon, Strobel & Laureau,
226 Walnut St., Phila.

Graff, Frederic, (*Director*), Jan. 18th, 1879.
Hydraulic Engineer,
1337 Arch St., Phila.

Graham, John, Jr., May 1st, 1880.
General Manager Camden Iron Works,
Camden, N. J.

Graham, Thomas H., Dec. 4th, 1880.
Manager Mining Co., Cuba,
400 Chestnut St., Phila.

Gray, Wm. J., May 6th, 1882.
Mechanical Engineer,
3409 Walnut St., Phila.

Gwilliam, G. T., Dec. 2d, 1882.
Sanitary Engineer,
115 N. 6th St., Phila.

Haig, Andrew H., Dec. 1st, 1883.
Mechanical Engineer,
1018 Chestnut St., Phila.

Hall, Willis E., Jan. 14th, 1882.
Mechanical Engineer,
P. O. Box 111, Altoona, Pa.

Hand, H., W., Jan. 12th, 1884.
Mech. Engr., I. P. Morris Co.,
1057 Richmond St., Phila.

Harden, John H., Jan. 17th, 1879.
General Mining Engineer Phœnix Iron Co.,
Box No. 4, Phœnixville, Chester Co., Pa.

Harden, O. B., Nov. 1st, 1884.
Asst. 2d Geol. Survey of Penna.,
907 Walnut St., Phila.

Hartley, Henry J., Jan 12th, 1884.
Supt. Smithy and Boiler Dept. Port Richmond Iron Works,
1057 Richmond St., Phila.

Haswell, Chas. H., July 1st, 1882.
Civil and Marine Engineer,
29 Broadway, P. O. Box 2961, New York City.

Haug, John, Oct. 4th, 1879.
Ship and Engineer Surveyor of Lloyd's Register of Shipping, London,
206 Walnut Place, Phila.

Haupt, Herman, Jr., April 7th, 1883.
Metallurgist,
Room 21, Gilfillan Block, St. Paul, Minn.

Haupt, Lewis M., Dec. 17th, 1877.
Professor of Civil Engineering, University of Penna.,
34th and Locust Sts., Phila.

Heller, Chas. S., Oct. 4th, 1879.
Designer and Manufacturer of Engineers' Field Instruments,
Ridge Ave. and Spring Garden St., Phila.

Henderson, Geo. R., Feb. 20th, 1886.
Mech. Engr., P. R. R.,
Altoona, Pa.

Henderson, John W., March 7th, 1885.
Mech. Engr. Wharton Switch Co.,
1306 Arch St., Phila.

Henszey, Wm. P., May 17th, 1884.
Mech. Engr. Baldwin Locomotive Works,
500 N. Broad St., Phila.

Hering, Carl O., Jan. 14th, 1882.
Electrical Engineer,
112 N. 12th St., Phila.,

Hering, Rudolph, (*Director*), Feb. 2d, 1878.
Consulting Civil and Sanitary Engineer,
326 Walnut St., Phila.

Heston, Walter D., March 15th, 1884.
Civil Engineer,
4941 Lancaster Ave., Phila.

Hewitt, Geo. W., June 20th, 1885.
Architect,
310 Chestnut St., Phila.

Hill, Frank A., Nov. 1st, 1884.
Asst. Geologist, 2d Geol. Surv. of Pa.,
907 Walnut St., Phila.

Hirsh, H. B., May 2d, 1885.
Civil Engineer,
1318 Marshall St., Phila.

Hoffman, John R., Dec. 6th, 1884.
Div. Engr. P. & R. C. & I. Co.,
Pottsville, Pa.

Holliday, Robert L., June 21st, 1884.
Supt. Bedford Div. P. R. R.,
Bedford, Bedford Co., Pa.

Hood, Geo. G., Jan. 24th, 1885.
Asst. Engr. P. & R. R. R.,
Mt. Airy, Phila.

Hoopes, Barton, Jr., Nov. 1st, 1884.
Mech. Engr. Hoopes & Townsend,
1330 Buttonwood St., Phila.

Hoopes, Herman, Dec. 17th, 1877.
Civil Engineer,
609 Chestnut St., Phila.

Hoopes, John J., Oct. 16th, 1880.
Civil Engineer,
Belfast, Lee Co., Iowa.

Howell, Benj. P., May 17th, 1884.
Engineer of Mines, H. C. Frick Coke Co.,
Scottdale, Pa.

Howell, Edward I. H., Jan. 18th, 1879.
Mechanical Engineer,
51 N. Seventh St., Phila.

Howland, Arthur H., March 7th, 1885.
Civil Engineer,
U. S. Hotel, Boston, Mass.

Hoyt, Allen V., June 16th, 1883.
Civil Engineer,
Philipsburg, Centre Co., Pa.

Hoyt, Wm. J., May 2d, 1885.
Engineer and Machinist,
422 Broadway, Camden, N. J.

Hoyt, W. L., Feb. 20th, 1886.
Mechanical Engineer,
333 E. Fulton St., Lancaster, Pa.

Hunt, Conway B., Dec. 6th, 1884.
Asst. Engr. Penna. R. R.,
Room 7, Union Station, Pittsburgh, Pa.

Hunter, W., April 19th, 1884.
Asst. Engr. P. & R. R. R.,
227 S. 4th St., Phila.

Hutchinson, Edward S., April 7th, 1883.
Civil and Mining Engineer,
Newtown, Bucks Co., Pa.

Hutchinson, J. B., Oct. 4th, 1884.
Supt. Altoona Div. P. R. R.,
Altoona, Pa.

Ingham, Wm. A., (*Director*), Feb. 2d, 1878.
President Rockhill Iron & Coal Co.,
320 Walnut St., Phila.

Ingles, William, Jan. 12th, 1884.
Asst. Engr. N. & W. R. R.,
New River, Pulaski Co., Va.

Ives, Theo. C., June 16th, 1883.
Chief Engr. Otis Elevating Ry. Co.,
Catskill, N. Y.

Jamison, Samuel, June 14th, 1882.
Civil Engineer,
1908 Walnut St., Phila.

Janeway, J. J., June 16th, 1883.
Asst. Engr. S. P. R. R.,
Everett, Bedford Co., Pa.

Janney, Morris P., March 7th, 1885.
Mechl. and Blast Furnace Engineer,
Leesport, Pa.

Janvier, Thomas G., Jan. 14th, 1882.
Asst. Engineer Fairmount Park,
Park Office, Belmont, Phila.

Jarvis, Chas. M., Jan 24th, 1885.
Vice Pres. and Chief Engr. Berlin Iron Bridge Co.,
East Berlin, Conn.

Jenny, Karl, Jan. 14th, 1882.
Civil Engineer with Southern R. R. of Austria,
III Salesianergasse 33, Vienna, Austria.

Johnson, Joseph, Dec. 4th, 1880.
Surveyor and Regulator 11th Survey District, Phila.,
501 N. 40th St., Phila.

Johnston, Edward H., June 20th, 1885.
Supt. Wharton Switch Co.,
3720 Hamilton St., Phila.

Jones, Llewellyn W., Feb. 20th, 1886.
Mech. Engr., P. R. R. Co.,
Altoona, Pa.

Jones, Richard W., March 15th, 1884.
Asst. Engr. M. of W. Brooklyn Elevated R. R.,
51 Fulton St., Brooklyn, N. Y.

Jones, Washington, (*President*), May 6th, 1882.
Supt. Port Richmond Iron Works,
1632 N. 15th St., Phila.

Jones, W. H., June 21st, 1884.
Surveyor and Regulator 12th District,
4001 Sansom St., Phila.

King, Jos. B., Nov. 7th, 1885.
Foreman of Machine Shop, Midvale Steel Co.,
Nicetown, Phila.

Kneass, Strickland L., Oct. 16th, 1880.
Mechanical Engineer with Wm. Sellers and Co.,
418 S. 15th St., Phila.

Laureau, Louis G., Dec. 5th, 1885.
Mech. Engr. Gordon, Strobel & Laureau,
226 Walnut St., Phila.

Lee, Harry K., Dec. 2d, 1882.
Mechanical Engineer,
Hartford, Conn.

Lee, Preston B., June 16th, 1883.
Mechanical Engineer,
3925 Lancaster Ave., Phila.

Lee, R. H., Nov. 19th, 1881.
Supt. Logan Iron & Steel Co.,
Lewistown, Pa.

Lehman, Ambrose E., Feb. 2d, 1878.
Asst. Geologist Penna. Geol. Survey,
711 Walnut St., Phila.

Lesley, Robert W., March 15th, 1884.
Hydraulic Cement Manufacturer,
312 S. 15th St., Phila.

Levering, Wm. M., Jan 24th, 1885.
P. A. Engr. Wilson Bros. & Co.,
435 Chestnut St., Phila.

Lewis, Fredk. H., Feb. 20th, 1886.
Civil Engineer,
14 Woodland Terrace, Phila.

Lewis, Theo. J., March 15th, 1884.
Mech. Engr. Standard Steel Works,
220 S. 4th St., Phila.

Lewis, Wilfred, Dec. 17th, 1877.
Mechanical Engineer with Wm. Sellers & Co.,
33d and Powelton Ave., Phila.

Lillie, S. Morris, March 5th, 1881.
Chemist Franklin Sugar Refinery,
101 S. Front St., Phila.

Lindroth, Carl O., Feb. 20th, 1886.
Mechanical Engineer,
1336 Mole St., Phila.

Linton, Harvey, Jan. 12th, 1884.
Civil Engineer,
906 Walnut St., Phila.

Little, J. Kay, April 7th, 1883.
Asst. Engr. Phila. Survey Dept.,
City Hall, Phila.

Livingston, Max, May 2d, 1885.
Supt. Atlantic Refining Co.,
307 Walnut St., Phila.

Loiseau, E. F., April 7th, 1883.
Mechanical Engr.,
65 rue de la Victóire, Brussels, Belgium.

Longstreth, Edward, June 20th, 1885.
Mech. Engr., Baldwin Locomotive Works,
1805 Spring Garden St., Phila.

Loomis, Thomas H., Nov. 1st, 1884.
Asst. Engr. S. P. R. R.,
Eby Building, Harrisburg, Pa.

Loss, Henry W., April 19th, 1884.
Mech. Engr. Edge Moor Iron Works,
Wilmington, Del.

Low, Emile, Nov. 7th, 1885.
Asst. Engr. P. & M. R. R.,
Hazelton, Luzerne Co., Pa.

Low, Theo., Nov. 7th, 1885.
Asst. Engr. P. S. V. R. R.,
Pottsville, Schuylkill Co., Pa.

Lüders, Harrison C., May 21st, 1881.
Secretary Phosphor-Bronze Smelting Co., Lim.,
206 S. 41st St., Phila.

Lüders, Theo. H., April 19th, 1884.
Supt. Phosphor-Bronze Smelting Co.,
512 Arch St., Phila.

Ludlow, Edwin, April 2d, 1881.
Supt. Union Coal Co.,
Shamokin, Pa.

Ludlow, William, (*Director*), Oct. 2d, 1880.
Major Corps of Engineers, U. S. A.,
2215 St. James' Place, Phila.

Lukens, Lewis N., Dec. 5th, 1885.
Mech. Engr., Alan Wood & Co.,
Conshohocken, Pa.

Luther, R. C., Feb. 20th, 1886.
Mining Engr., P. & R. Coal and Iron Co.,
Pottsville, Pa.

Lyman, Frank, Oct. 4th, 1879.
Manager Stack Mine, Backbone, Va.,
34 Remsen St., Brooklyn, N. Y.

Maddock, Frank, Jan. 12th, 1884.
Engineer Roanoke Land & Imp. Co.,
Roanoke, Roanoke Co., Va.

Madeira, Louis C., Jr., Feb. 16th, 1878.
Civil Engineer,
322 Walnut St., Phila.

Magalhaes, Antonio C., Jan. 14th, 1882.
Civil Engineer,
923 Walnut St., Phila.

Marshall, Samuel R., April 19th, 1884.
Mechanical Engineer,
923 N. Broad St., Phila.

Marston, John, Jr., April 2d, 1881.
Civil Engineer,
133 S. 4th St., Phila.

Martin, W. K., June 20th, 1885.
Asst. Engr. P. W. & B. R. R.,
Wilmington, Del.

Matlack, D. J., May 21st, 1881.
Foreman of Foundry, Port Richmond Iron Works,
1515 Marshall St., Phila.

Matsdaira, T. A. M., May 17th, 1884.
City Engineer,
Bradford, Pa.

Matton, F. V., April 19th, 1884.
Mech. Engr., Camden Iron Works,
Camden, N. J.

May, DeCourcy, March 15th, 1884.
Asst. Supt. I. P. Morris Co.,
1230 Spruce St., Phila.

McArthur, Chas. P., Jan. 24th, 1885.
Asst. Engr. P. R. R.,
Altoona, Pa.

McCallum, Wm. H., Nov. 1st, 1884.
Mech. Engr., Supt. New Glen Echo Mills,
Germantown, Phila.

McClellan, Oliver E., March 1st, 1879.
Supt. Mid. Div. Penna. R. R. Co.,
Harrisburg, Pa.

McClure, James R., Feb. 5th, 1881.
Civil Engineer P. R. R.,
233 S. 4th St., Phila.

McCollom, Thos. C., April 20th, 1878.
Civil Engineer U. S. Navy,
Civil Engr.'s Office, U. S. Navy Yard, N. Y.

McCombe, S. Craige, Nov. 1st, 1884.
Supervisor P. R. R.,
Downingtown, Pa.

McCorkle, Spencer C., Oct. 4th, 1884.
Asst. U. S. C. & G. Survey,
Room 5, U. S. C. H. & P. O. Bdg., 9th and Chestnut Sts., Phila.

McFadden, Dr. Wm. H., Jan. 18th, 1879.
American Meter Co.,
22d and Arch Sts., Phila.

McIlvaine, William, Jan. 13th, 1883.
Civil Engineer,
4025 Chestnut St., Phila.

McKee, Jos. J., March 15th, 1884.
Mechanical Engineer and Manufacturer,
Bethlehem, Pa.

Megear, Alter, May 17th, 1884.
Civil Engineer,
3306 Arch St., Phila.

Mencke, Wm. F., Dec. 5th, 1885.
Mech. Engr., Southwark Foundry and Machine Co.,
430 Washington Ave., Phila.

Mercer, Joseph, Feb. 5th, 1881.
Surveyor and Regulator 6th Survey District, Phila.,
1845 Frankford Ave., Phila.

Merriam, Chas. A., Jan. 10th, 1880.
Genl. Supt. Mexican Natl. Ry.,
Laredo, Texas.

Merriman, Mansfield, June 18th, 1881.
Professor of Civil Engineering,
Lehigh University, Bethlehem, Pa.

Michaelis, O. E., Oct. 4th, 1884.
Capt. of Ordnance U. S. A.,
Watervliet Arsenal, West Troy, N. Y.

Middleton, Chas. H., Jr., Jan. 24th, 1885.
Asst. Engr. Penna. R. R.,
Room 7, Union Station, Pittsburgh, Pa.

Millard, William H., March 15th, 1884.
Civil Engineer, Wilson Bros. & Co.,
3006 Frankford Ave., Phila.

Miller, Francis L., Jan. 10th, 1880.
Civil Engineer,
3d Div., Panama Canal, Panama, U. S. Colombia.

Miller, Geo. L., Dec. 2d, 1882.
Civil and Mining Engineer,
Houtzdale, Pa.

Millholland, Henry, June 16th, 1883.
Mechanical Engineer,
1327 Sixth Ave., Altoona, Pa.

Mitchell, A. G., June 20th, 1885.
Asst. Supervisor P. R. R.,
3202 Arch St. Phila.

Mitchell, Sam'l P., May 2d, 1885.
Asst. Engr. Phila. Branch B. & O. R. R.,
Havre de Grace, Md.

Moore, C. Frederick, Dec. 6th, 1884.
Civil and Sanitary Engineer,
744 N. 40th St., Phila.

Mordecai, Augustus, March 6th, 1880.
Assistant Engineer New York, Penna. & Ohio R. R. Co.,
Cleveland, Ohio.

Morris, A. Saunders, Dec. 5th, 1885.
Mech. Engr.,
209 S. 3d St., Phila.

Morris, Gouverneur, April 2d, 1881.
Assistant Supt. Lehigh Coal and Nav. Co.,
Lansford, Carbon Co., Pa.

Morris, Henry G., (*Director*), Feb. 2d, 1878.
Mechanical Engineer and Machinist,
209 S. Third St., Phila.

Morris, Israel W., April 20th, 1878.
Treasurer Lehigh Valley Coal Co.,
228 S. 3d St., Phila.

Mucklé, John S., April 7th, 1883.
Mechanical Engineer with M. R. Mucklé, Jr.,
Rooms 16 and 17, Ledger Building, Phila.

Mucklé, M. Richards, Jr., Dec. 17th, 1877.
Engineer and Machinist,
Rooms 16 and 17, Ledger Building, Phila.

Mullen, John, Dec. 6th, 1884.
Mgr. and Propr. Shamokin Iron Works,
Shamokin, Northumberland Co., Pa.

Munroe, Henry S., Feb. 5th, 1881.
Adj. Prof. Practical Mining,
School of Mines, Columbia College, N. Y. City.

Murphy, Howard, (*Secretary and Treasurer*), March 16th, 1878.
Civil Engineer,
326 Walnut St., Phila.
Official, Club address—1122 Girard Street, Philadelphia, Pa.

Murphy, John H., March 5th, 1881.
Supervisor Penna. R. R. Co.,
Columbia, Lancaster Co., Pa.

Nauman, Wm. H., July 1st, 1882.
P. A. Engineer U. S. N.,
Navy Dept., Washington, D. C.

Naylor, John S., April 19th, 1884.
Mechanical Engineer,
Front St. and Girard Ave., Phila.

Neff, Stewart S., April 19th, 1884.
Asst. Supervisor P. R. R.,
Bellefonte, Pa.

Neilson, Wm. G., Dec. 17th, 1877.
Manager Standard Steel Works,
220 S. 4th St., Phila.

Newbold, John D., Jan. 24th, 1885.
Mechanical Engr. and Mfr.,
Eagle Works, Norristown, Pa.

Newhall, Geo. M., Dec. 6th, 1884.
Genl. Mgr. Phila. Sugar Refinery,
225 Church St., Phila.

Nichol, James H., March 7th, 1885.
Supervisor W. J. R. R.,
Millville, N. J.

Nichols, Edward, Dec. 1st, 1883.
President Ridge Valley Iron Co.,
Hermitage, Ga.

Nichols, Henry K., April 19th, 1884.
Chief Engineer P. & R. R. R.,
227 S. 4th St., Phila.

Nute, John W., April 19th, 1884.
Asst. Engr. Western Div. W., St. L. & P. Ry.,
Moberly, Mo.

Ogden, John L., May 1st, 1880.
Chief Engineer Phila. Water Department,
72d and Greenway Ave., Phila.

Opperman, Jesse, Nov. 19th, 1881.
Assistant Engineer Duluth & Winnipeg R. R.,
Duluth, Minn.

Osborne, J. Godolphin, May 1st, 1880.
Train Master New River Div., N. & W. R. R.,
Lovely Mount, Montgomery Co., Va.

Osborne, Percy T., March 7th, 1885.
Civil Engineer,
302 Walnut St., Phila.

Osler, Wm. P., Feb. 5th, 1881.
Civil Engineer,
602 N. 5th St., Camden, N. J.

Ott, C. Henry, Jan. 12th, 1884.
Civil Engineer and Sur. Anniston Land and Imp. Co.,
Anniston, Ala.

Paddock, F. L., Nov. 19th, 1881.
Asst. Engr. Phila. Water Dept.,
P. O. Box 838, Phila.

Paddock, Geo. H., June 16th, 1883.
Engineer Manayunk Sewer, Phila.,
4827 Haverford St., Phila.

Parrish, Edward, Jan. 18th, 1879.
Civil Engineer,
29 Benevolent St., Providence, R. I.

Parry, William A., March 15th, 1884.
Iron,
208 S. 4th St., Phila.

Patterson, John Curtis, July 1st, 1882.
Civil Engineer,
1919 Spruce St., Phila.

Patton, W. M., Dec. 5th, 1885.
Engineer in Charge Schuylkill River Bridge, B. & O. R. R.,
Gray's Ferry, Phila.

Pettit, Robert E., Jan. 9th, 1886.
Gen'l Supt. Pa. R. R. Co.,
Altoona, Pa.

Philips, Ferdinand, Dec. 6th, 1884.
Supt. Engr. Hoopes & Townsend,
1330 Buttonwood St., Phila.

Pistor, Philip, Nov. 1st, 1884.
Mechanical Engr., Warden & Mitchell,
2127 N. 12th St., Phila.

Pott, John N., May 17th, 1884.
Civil and Mining Engineer,
833 Hamilton St., Allentown, Pa.

Potts, Wm. M., Feb. 2d, 1878.
Manager Isabella Furnace,
Barneston, Chester Co., Pa.

Preston, C. A., July 1st, 1882.
Supervisor Northern Central Railway,
Union Station, Baltimore, Md.

Prevost, Sutherland M., Nov. 7th, 1885.
Genl. Supt. Transportation, P. R. R.,
233 S. 4th St., Phila.

Price, Geo. B., May 2d, 1885.
Mech. Engr., Baldwin Locomotive Works,
128 N. 12th St., Phila.

Pusey, Chas. W., Jan. 14th, 1882.
Mechanical Engineer with the Pusey & Jones Co.,
1110 Washington St., Wilmington, Del.

Rea, Samuel, May 6th, 1882.
Principal Assistant Engineer Penna. R.R.,
233 S. 4th St., Phila.

Reeves, David, Oct. 2d, 1880.
President Phœnix Iron Co.,
410 Walnut St., Phila.

Reilly, Thomas A., Jan. 24th, 1885.
Engineer and Contractor,
Pottsville, Pa.

Reilly, William B., April 19th, 1884.
Mech. Engr. Jos. Oat & Sons,
232 Quarry St., Phila.

Richardson, B. Frank, Jan. 12th, 1884.
Div. Engr. Balt. & Ohio R. R.,
1604 S. 11th St., Phila.

Ridgway, Wm. H., March 5th, 1881.
Mechanical Engineer and Manufacturer,
Coatesville, Chester Co., Pa.

Riegner, W. B., Oct. 4th, 1884.
Civil Engineer,
413 Walnut St., Phila.

Roberts, Alfred R., Feb. 2d, 1878.
Civil Engineer,
310 N. 33d St., Phila.

Roberts, Geo. B., Nov. 19th, 1881.
President Penna. R. R. Co.,
233 S. 4th St., Phila.

Roberts, Percival, March 1st, 1879.
Iron Manufacturer,
261 S. 4th St., Phila.

Roberts, Percival, Jr., Dec. 17th, 1877.
Mechanical Engineer,
Pencoyd Iron Works, 261 S. 4th St., Phila.

Roberts, Thos. A., May 21st, 1881.
Supt. Mid. Div. P. & E. R. R.,
Renovo, Pa.

Robinson, Fredc. H., Feb. 20th, 1886.
City Engineer,
Wilmington, Del.

Robinson, Wm. H., June 21st, 1884.
Mech. Engr. Baldwin Locomotive Works,
2141 N. 12th St., Phila.

Rohrer, Jacob B., Nov. 7th, 1885.
Div. Engr. P. & M. R. R.,
Saint Clair, Schuylkill Co., Pa.

Rogers, Fairman, Feb. 2d, 1878.
Civil Engineer,
202 W. Rittenhouse Square, Phila.

Rogers, T. Mellon, April 7th, 1883.
Asst. Engr. Phila. Water Dept.,
13th and Spring Garden Sts., Phila.

Roney, C. H., April 2d, 1881.
Mining and Civil Engineer,
110 S. 4th St., Phila.

Root, W. J., Jan. 13th, 1883.
Mechanical Engineer with Henry R. Worthington,
145 Broadway, N. Y. City.

Rosenberg, Friedrich, Jan. 12th, 1884.
Asst. Supervisor P. R. R.,
Harrisburg, Pa.

Rowbottom, James, March 15th, 1884.
Foreman Mach. Dept. Wm. Cramp & Sons S. & E. B. Co.,
1936 N. Front St., Phila.

Rudderow, Morris W., Jan. 13th, 1883.
Mechanical Engineer with Geo. V. Cresson,
527 N. 19th St., Phila.

Rutter, Chas. A., Oct. 16th, 1880.
Mechanical Engineer,
424 Walnut St., Phila.

Salom, Pedro G., Nov. 7th, 1885.
Metallurgist and Chemist,
208 S. 4th St., Phila.

Samuel, Edward, March 16th, 1878.
Vice Pres. of Wm. Wharton, Jr., & Co., Limited,
1800 DeLancey Place, Phila.

Sanborn, H. W., Nov. 1st, 1884.
Asst. Engr. Phila. Water Dept.,
P. O. Box 838, Phila.

Sanders, Richard H., Jan. 18th, 1879.
Civil Engineer and Geologist,
737 Walnut St., Phila.

Sanne, Oscar, June 21st, 1884.
Civil Engineer,
Care of C. Shaler Smith, C. E.,
Bridge Entrance, St. Louis, Mo.

Sargent, F. W., Dec. 6th, 1884.
Asst. Engr. of Tests, C. B. & Q. R. R.,
Box 1962, Aurora, Ill.

Sayen, W. Henry, May 17th, 1884.
Consulting Mechanical Engineer,
107 S. 8th St., Phila.

Saylor, Francis H., March 5th, 1881.
Civil Engineer and Bridge Builder,
257 S. 4th St., Phila.

Schick, James R., April 19th, 1884.
Asst. Engineer N. & W. & S. V. R. Rs.,
Roanoke, Roanoke Co., Va.

Schutte, Louis, May 2d, 1885.
Mech. Engr. and Machinist,
12th and Thompson Sts., Phila.

See, Horace, Jan. 10th, 1880.
Supt. Engineer of the Wm. Cramp & Sons S. & E. B. Co.,
Foot of Norris St., Phila.

Seitz, Earl M., May 6th, 1882.
Asst. Engineer Penna. R. R.,
512 N. 5th St., Phila.

Sellers, Coleman, Jan. 12th, 1884.
Mechanical Engineer,
1600 Hamilton St., Phila.

Sellers, Coleman, Jr., Dec. 17th, 1877.
Mechanical Engineer with Wm. Sellers & Co.,
332 N. 33d St., Phila.

Sellers, Horace W., Dec. 17th, 1877.
Mechanical Engineer,
3301 Baring St., Phila.

Sellers, Howard, Dec. 17th, 1877.
Mechanical Engineer with Wm. Sellers & Co.,
3300 Arch St., Phila.

Sellers, William, June 21st, 1884.
Mechanical Engineer,
1600 Hamilton St., Phila.

Sellers, Wm. F., Dec. 17th, 1877.
Foreman Edge Moor Iron Co.,
Wilmington, Del.

Seymour, R. C., Jan. 13th, 1883.
Mechanical Engineer with Bullock Printing Press Co.,
52 Illinois St., Chicago, Ill.

Sheafer, Arthur W., March 1st, 1879.
Mining Engineer,
Pottsville, Pa.

Sheafer, Walter S., April 19th, 1884.
Mining Engineer,
Pottsville, Pa

Simpson, Wm. L., April 7th, 1883.
Supt. Kensington Engine Works,
Beach and Vienna Sts., Phila.

Sims, A. W., March 7th, 1885.
Engr. and Supt. E. Broad Top R. R. and Furnaces,
Orbisonia, Huntingdon Co., Pa.

Sims, H. N., June 20th, 1885.
Mining Engineer and Geologist,
314 Penn St., Huntingdon, Pa.

Smedley, Samuel L., Jan. 18th, 1879.
Chief Engineer and Surveyor Phila. Survey Department,
City Hall, Phila.

Smith, Albanus L., Jan. 9th, 1886.
Asst. Engr. Manly & Cooper Manufacturing Co.,
No. 6 East Penn St., Germantown, Phila.

Smith, Edwin F., June 28th, 1881.
Chief Asst. Engr. P. & R. R. R.,
Reading, Pa.

Smith, Henry C., Oct. 4th, 1884.
Civil Engineer,
Box 4, Media, Penna.

Smith, Joseph S., March 5th, 1881.
Civil Engineer,
22 N. 6th St., Phila.

Smith, T. Carpenter, Oct. 2d, 1880.
Mechanical Engineer,
3303 Hamilton St., Phila.

Smith, W. Bugbee, March 5th, 1881.
Mechanical Engineer,
407 Walnut St., Phila.

Snowden, Robert P., Dec. 2d, 1882.
Assistant Engineer, Penna. R. R.,
Camden, N. J.

Soule, Richard H., Jan 18th, 1879.
Supt. Motive Power, N. Y., L. E. & W. R. R., & N. Y., P. & O. R. R.,
Buffalo, N. Y.

Spangler, H. W., Dec. 1st, 1883.
Engineer U. S. N.,
Box 532, Carlisle, Pa.

Spencer, Graham, May 21st, 1881.
Supt. American Kaolin Works,
Kaolin P. O., Chester Co., Pa.

Stauffer, David McN., Feb. 2d, 1878.
Consulting Engr., Ed. "Engineering News,"
12 Tribune Building, N. Y. City.

Stearns, Irving A., June 16th, 1883.
Mining and Civil Engineer,
Wilkes-Barre, Pa.

Stevenson, A. A., May 17th, 1884.
Mechanical Engineer,
420 S. 15th St., Phila.

Stewart, Harry G., March 15th, 1884.
Mechanical Engineer,
1130 Mt. Vernon St., Phila.

Stewart, James M., Oct. 2d, 1880.
Civil Engineer,
Caldwell, Ada Co., Idaho.

Stewart, S. N., June 21st, 1884.
Mechanical Engineer,
3041 Dauphin St., Phila.

Storrs, Arthur H., March 7th, 1885.
Supt. J. Langdon & Co. Collieries,
Shamokin, Pa.

Strobel, Victor O., Dec. 5th, 1885.
Mech. Engr., Gordon, Strobel & Laureau,
226 Walnut St., Phila.

Strong, George S., May 21st, 1881.
Mechanical Engineer,
701 Chestnut St., Phila.

Sundstrom, C. A., June 20th, 1885.
Asst. Engr. P. R. R.
Sumac St., Wissahickon, Phila.

Taft, P. W., Jan. 24th, 1885.
Manager Benj. Atha & Co., Newark Steel Works,
234 N. Front St., Phila.

Taylor, Chas. E., June 20th, 1885.
Civil Engineer,
816 N. 21st St., Phila.

Taylor, Frank H., May 2d, 1885.
Sec. and Treas. Manly & Cooper Mfg. Co.,
42d and Elm Ave., Phila.

Taylor, Frederick W., April 20th, 1878.
Engineer Midvale Steel Co.,
Nicetown, Phila.

Taylor, P. A., March 15th, 1884.
Div. Engr. P. & R. R. R.,
Pottsville, Schuylkill Co., Pa.

Thayer, Russell, Feb. 5th, 1881.
Supt. Fairmount Park, Phila., and Civil and Sanitary Engr.,
City Hall, Phila.

Thiange, Edward, June 16th, 1883.
Civil Engineer,
325 Walnut St., Phila.

Thomas, Geo. C., Oct. 4th, 1879.
Sec. and Treas. Jersey City Car Wheel Fdy. and Machine Works,
P. O. Box 129, Jersey City, N. J.

Thompson, Chas. T., May 1st, 1880.
Mechanical Engineer with I. P. Morris Co.,
1057 Richmond St., Phila.

Thompson, Gaylord, May 17th, 1884.
Resident Engr. S. P. R. R..
Everett, Bedford Co., Pa.

Thompson, Heber S., May 2d, 1885.
Civil and Mining Engr., Girard Estate,
Room 14, Morris Building, Pottsville, Schuylkill Co., Pa.

Titlow, J. Milton, Jan. 18th, 1879.
Principal Assistant Engineer Survey Department,
City Hall, Phila.

Towne, Linwood O., May 1st, 1880.
Assayer, Chemist and Mining Engr.,
Rico, Colorado.

Townsend, David, Jan. 10th, 1880.
Mechanical Engineer with Bush Hill Iron Works,
1723 Wallace St., Phila.

Townsend, Henry T., Jan. 13th, 1883.
President Logan Iron & Steel Co.,
218 S. 4th St., Phila.

Trautwine, John C., Jr., Jan. 12th, 1884.
Civil Engineer,
262 S. 4th St., Phila.

Tripler, Henry E., Nov. 7th, 1885.
Asst. Engr. R. & P. R. R.,
Merchants' Hotel, Pottsville, Pa.

Trump, Michael, Jan. 10th, 1880.
Asst. Supt. Pittsburgh Div. Penna. R. R. Co.,
Union Depot, Pittsburgh, Pa.

Turner, Geo., Jr., Dec. 6th, 1884.
Mech. Engr. Siemens Reg. Gas Lamp Co.,
4042 Sansom St., Phila.

Turner, Geo. A., March 5th, 1881.
Mechanical Engineer, Locomotive Supt.'s Office,
Christ Church, Canterbury, New Zealand.

Tyson, A. Harvey, July 1st, 1882.
City Engineer,
City Hall, Reading, Pa.

Vandevanter, C. O., Dec. 2d, 1882.
Asst. Eng., East Broad Top R. R. & Coal Co.,
Orbisonia, Huntingdon Co., Pa.

Van Harlingen, M., April 2d, 1881.
Civil Engineer,
415 Wyoming St., West Phila.

Vezin, H. A., Jan. 18th, 1879.
Civil and Mining Engineer,
P. O. Box 144, Leadville, Col.

Vogdes, Jesse T., Jr., March 15th, 1884.
Asst. Engr. Fairmount Park,
629 N. 40th St., Phila.

Vogt, Axel S., Jan. 10th, 1880.
Asst. Engr. of Tests P. R. R.,
Altoona, Pa.

Waddell, J. A. L., Dec. 2d, 1882.
Professor of Civil Engineering,
University of Tokio, No. 5 Kaga Yashiki, Tokio, Japan.

Waddell, Robt. W., Dec. 1st, 1883.
Asst. Engr. Colorado Trust Co.,
Plathville, Weld Co., Col.

Wagner, Samuel T., Feb. 20th, 1886.
Asst. Master Mechanic Phœnix Iron Works,
Phœnixville, Pa.

Walbridge, W. G., July 1st, 1882.
Assistant Engineer Department of Surveys,
5125 Adams St., Germantown, Phila.

Wallace, Edward R., March 15th, 1884.
Civil Engineer,
63 N. 34th St., Phila.

Ward, Joseph S., Jan. 24th, 1885.
Asst. Supervisor P. & R. R. R.,
9th and Columbia Ave., Phila.

Warren, B. F., Feb. 16th, 1878.
Manager Ocean Oil Co., etc.,
1708 Mt. Vernon St., Phila.

Webster, Geo. S., Jan. 18th, 1878.
Surveyor and Regulator 10th Phila. Survey District,
4626 Frankford Ave., Phila.

Wells, Bard, Nov. 1st, 1884.
Min. Engr. and Geologist,
Pottsville, Pa.

Wentworth, Chas. C., Dec. 4th, 1880.
P. A. Engineer Construction Department, N. & W. R. R.,
Roanoke, Roanoke Co., Va.

West, Preston C. F., March 5th, 1881.
Civil and Mining Engineer, Calumet and Hecla Mine,
Calumet, Houghton Co., Mich.

Wetherill, Robert, Dec. 6th, 1884.
Mech. Engr. and Mfr.,
Chester, Pa.

Wetherill, W. C., May 6th, 1882.
Locating Engr. Beech Creek, Clearfield & S. W'n. R. R.,
Jersey Shore, Pa.

Wharton, William, Jr., March 15th, 1884.
Engineer and Manufacturer,
Cottage Lane, Germantown, Phila.

Wharton, W. Rodman, Jan. 18th, 1879.
Mechanical Engineer,
911 Pine St., Phila.

White, Arthur M., Dec. 2d, 1882.
Supt. New York Locomotive Works,
Rome, N. Y.

Whiting, Stephen B., April 19th, 1884.
Gen'l Manager P. & R. Coal and Iron Co.,
Pottsville, Pa.

Wiley, Wm. H., Nov. 1st, 1884.
Civil Engineer,
15 Astor Place, N. Y.

Williams, Dr. Edward H., Oct. 4th, 1884.
Burnham, Parry, Williams & Co.,
33d and Arch Sts., Phila.

Williams, Samuel T., Jan. 9th, 1886.
Mech. Engr., Gen'l Mgr. Steel Department Henry Disston & Sons,
Tacony, Phila.

Williamson, T. Roney, Jan. 10th, 1880.
Architect,
Room 26, Merchants' Exchange, 3d and Walnut Sts., Phila.

Wilson, E. A., Jan. 12th, 1884.
Engr. in Charge C. C. Ext., N. R. Div., N. & W. R. R.,
Luray, Page Co , Va.

Wilson, John, Nov. 7th, 1885.
Engineer Phila. Traction Co.,
23d and Brown Sts., Phila.

Wilson, John A., Jan. 18th, 1879.
Civil Engineer,
435 Chestnut St., Phila.

Wilson, Joseph B., May 17th, 1884.
Iron,
209 S. 3d St., Phila.

Wilson, J. Chester, April 19th, 1884.
Gen'l Manager Novelty Electric Co.,
5th and Locust Sts., Phila.

Wilson, Joseph M., June 21st, 1884.
Civil Engineer and Architect,
435 Chestnut St., Phila.

Wingate, E. B., Dec. 5th, 1885.
Chief Engr. K. C. & S. W. R. R.,
Arkansas City, Kansas.

Wingate, J. H., May 6th, 1882.
Civil Engineer,
Wytheville, Va.

Wister, Jones, April 19th, 1884.
Metallurgist,
230 S. 4th St., Phila.

Wood, Howard, Dec. 5th, 1885.
Manager Alan Wood & Co.,
Conshohocken, Pa.

Wood, James F., June 21st, 1884.
Engineer and Machinist,
703 Arch St., Phila.

Wyeth, Charles, June 20th, 1885.
Civil Engineer,
New Dorp, Staten Id., N. Y.

Yocum, Jacob H., May 21st, 1881.
Engineer Water Works,
Box 14, Columbus, Ga.

Young, Chas. A., Dec. 17th, 1877.
Geologist,
1741 Jefferson St., Kansas City, Mo.

Zacharias, Henry C., Dec. 5th, 1885.
Asst. Min. Engr. P. & R. C. & I. Co.,
Shamokin, Pa.

Ziegler, Wm. L., Jan 14th, 1882.
Engineer of Construction Penna. R. R.,
Broad St. Station, Phila.

Zook, M. A., April 7th, 1883.
Engineer Indianapolis Union Ry.,
Indianapolis, Ind.

ASSOCIATE MEMBERS.

Esherick, Frank K., Dec. 5th, 1885.
Iron and Steel,
263 S. 4th St., Phila.

Gordon, L. Frank, Dec. 5th, 1885.
With Gordon, Strobel & Laureau, Engineers,
226 Walnut St., Phila.

Moorhead, Wm. S., June 20th, 1885.
Mfr. Terra Cotta Pipe, etc.,
11 S. 7th St., Phila.

Schwacke, Justus H., June 20th, 1885.
Agent Wm. Sellers & Co.,
1600 Hamilton St., Phila.

Strawbridge, W. C., June 20th, 1885.
Patent Law and Patent Soliciting,
903 Walnut St., Phila.

Taylor, J. Bonsall, June 20th, 1885.
Patent Law and Patent Soliciting,
903 Walnut St., Phila.

Townsend, Edward Y., Dec. 6th, 1884.
President Cambria Iron Co., April 4th, 1885.
218 S. 4th St., Phila.

Townsend, John W., Oct. 5th, 1878.
Asst. to President Cambria Iron Co., April 4th, 1885.
218 S. 4th St., Phila.

DECEASED MEMBERS.

With date of election and of decease.

HONORARY MEMBER.

Trautwine, John C.,	Civil Engineer.	Jan. 10th, 1880. Sep. 14th, 1883.

CORRESPONDING MEMBERS.

Fry, Howard,	Mechanical Engineer.	Feb. 16th, 1878. April 27th, 1883.
McIlvaine, Rodman,	Civil Engineer.	Feb. 16th, 1878. Oct. 7th, 1878.

ACTIVE MEMBERS.

Bergner, Theodore,	Mechanical Engineer.	Dec. 6th, 1884. Jan. 5th, 1886.
Billin, Wm. L.,	Mining Engineer.	June 18th, 1881. Jan. 24th, 1883.
Cartwright, Henry,	Civil Engineer.	Jan. 18th, 1879. June 30th, 1881.
Faunt Le Roy, A. R.,	Civil Engineer.	June 21st, 1884. Dec. 26th, 1884.
Kneass, Strickland,	Civil Engineer.	Jan. 18th, 1879. Jan. 14th, 1884.
Knight, J. B.,	Mechanical Engineer.	April 6th, 1878. Mch. 10th, 1879.
Lorenz, William,	Civil Engineer.	May 6th, 1882. Dec. 29th, 1884.
Pierce, Dwight E.,	Mechanical Engineer.	Jan. 12th, 1884. Sep. 1st, 1885.
Shedaker, D. Hudson,	Civil Engineer.	Feb. 5th, 1881. Feb. 5th, 1885.
Wootten, Frederic C.,	Mechanical Engineer.	Mch. 15th, 1884. Nov. 16th, 1884.
Worrall, James,	Civil Engineer.	Oct. 2d, 1880. April 1st, 1885.

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